VOLUME V NUMBER 4

BULLETIN

OF THE

AMERICAN ASSOCIATION

OF

PETROLEUM GEOLOGISTS

RAYMOND C. MOORE
Editor

JULY—AUGUST, 1921

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

OFFICERS FOR 1921

GEORGE C. MATSON, *President*
Tulsa, Okla.

GEORGE C. GESTER, *Vice-President*
San Francisco, Calif.

CHARLES E. DECKER, *Secretary-Treasurer*
Norman, Okla.

RAYMOND C. MOORE, *Editor*
Lawrence, Kans.

E. DEGOLYER, *Advertising Manager*
65 Broadway, New York City

THE BULLETIN is the official publication of the Association, and it is to be published in six numbers with a subscription price of $5.00 per year. Extra postage on annual subscriptions is 30 cents for Canada and 53 cents for all other foreign countries to which postage is more than the local amount. Communications for the Editor and manuscripts should be addressed to R. C. Moore, Lawrence, Kansas. Remittances and business correspondence should be sent to C. E. Decker, Norman, Okla. Correspondence regarding advertisements should be addressed to E. DeGolyer, 65 Broadway, New York City.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

Vol. I	$2.50	Vol. IV, Nos. 1, 2, or 3, each	$2.00
Vol. II	2.50	Vol. V, Subscription, 1921	5.00
Vol. III	4.00	Vol. V, Nos. 1, 3, each	1.00
Vol. IV, 1, 2, 3	5.00	Vol. V, No. 2 (double size)	2.00

Vol. I, Sold only in complete sets.

Published by the American Association of Petroleum Geologists bimonthly, at Lawrence, Kansas. Entered as second class matter April 15, 1921 at the postoffice at Lawrence, Kansas under the Act of March 3, 1879. Claims for non-receipt of the preceeding Numbers of the Bulletin must be sent to the Editor within three months of the date of the receipt of this number in order to be filled gratis.

CONTENTS

Volume V. Number 4

BULLETIN

OF THE

AMERICAN ASSOCIATION

OF

PETROLEUM GEOLOGISTS

JULY—AUGUST, 1921

PETROLEUM GEOLOGY—ITS PAST AND ITS FUTURE

FOREWORD

By Sidney Powers

At a time when the price of oil in the Mid-Continent field has dropped from $3.50 to $1.00 a barrel in six months, when all oil companies are operating at a base margin of profit and have therefore reduced their organization to a minimum, it is an opportune time to inquire the relation of petroleum geology to the oil business, to ask what bearing geology has had to production in the past, and to interpret the future of the profession in terms of the past. In order to present this matter in broad aspect a few of the leaders of the profession have been asked to present brief papers touching on various phases of the subject. These papers are designed to discuss the work of geologists and not the development of oil fields and they do not attempt to tabulate the specific accomplishments of geologists.

Petroleum geology began only 36 years ago and it did not thrive until within the past score of years. Spindletop was discovered 20 years ago and the first oil well near Tulsa was completed during the same year. Cushing is scarcely 10 years old. Has this infant profession soared to its zenith and is it soon to start a slow decline to ultimately withdraw whence it came, to the United States Geological Survey? Or, is it to become stable and to persist as do branches of engineering?

The human element—the geologist—is, after all, the most important. Shall the petroleum geologist be a scientist advising the location of wells and nothing more, or shall he be an operator and drill the wells, or shall he take a midway stand and both direct the location and the drilling of wells? The petroleum geologist is not a pure scientist who proclaims his theories and takes no heed whether they are right or wrong; he is an applied scientist who lives by what he produces. He is a trained engineer in a business now dominated by men of little training, but with a strong venturesome spirit. Shall he not acquire this spirit and after another decade dominate the business?

THE SCIENCE OF PETROLEUM GEOLOGY

By E. G. Woodruff

Often I have been asked: "What is the future of petroleum geology?" Only one safe statement can be made and that is not really an answer to the question. The future of petroleum geology is to be co-incident with the history of the oil industry; it will continue to be used in locating and developing oil resources. Geology has been applied extensively in a practical way for nearly ten years. At first it was applied on the one hand by the promoter to help put over his wild and often unreasonable ideas and on the other hand by the very conservative business man who saw in it a means to better guard his funds by reducing his losses. Between these two extremes there are all sorts of employers of geology; it has been employed by so many practical oil producers that a fair test of the science has been given. All except a few erratics or unreasonably prejudiced men will concede that it is a success—that it certainly is a great aid to the industry.

Geology must be reckoned only as an aid. It should be introduced into a company—into the industry—as a new aid, a new tool to assist conditions already existing and not to supplant those conditions. Many of the attempts to use geology in the oil business have not been successful because the men who employed the geologist had an exaggerated idea of what he can do; he cannot see below the earth's surface, but he can

go a long way toward interpreting conditions below. One hopeful change is, however, taking place: geologists have thrown aside their ethical prejudices and are entering the oil business. These men, however, are not the subject of this paper.

The geological department need not supplant the land department but should select the land which that department leases. It should imbue the land department with information not hitherto possessed, the science should furnish men who can go to a tract of land and determine the promise of petroleum as compared with the surface conditions on tracts already producing. Fortunate is the company which can find a man with business ability to be successful at the head of its land department, who is a geologist and really understands the application of geology.

Another application of geology is to the study of subsurface conditions, the study of the formations to determine their productivity, to compare and compile data to determine the altitude of the strata below the surface.

If we accept these applications of the science then the future of the science and the future of the industry will be co-incident. As I read the historical curve of the industry for North America it is now near the crest of maximum production. For a few years—three to five—the present rate of production will be maintained approximately, then the long gradual decline will come. Possibly the permanent decline in production will begin about the time the world's business relations will have entered a period of permanent recovery from the present disrupted conditions which prevail as the result of the World's War. If this is true, in two or three years from now, there will be two controlling factors in the oil business; a growing market and a declining production. There will then be decidedly advanced prices resulting in a more intense search for new pools and a more intense development of old ones. However, no one should expect such abnormally good times as prevailed during the war. Because the most evident places will have been tested, less promising ones will be tried—more failures will be encountered, profits will be lessened, and the financiers' enthusiasm for the oil business will decrease, but will be good

for the next five or ten years. During this period excellently trained, experienced geologists will be in demand exclusively for geological work. Because there are many young men now trained and gaining their experience, the man coming from college will find it necessary to force his way into the profession rather than being sought as now. The man contemplating entering the profession should be aware that most of the men who are now in it are young and will have many years of active life before they will be removed by old age. They are advised to consider other phases of the industry where they can apply their training in competition with men who have not had the advantage of scientific education.

What will be the geologist's part in this improved business condition? It will be that of a trained engineer. Unless the geologists see the signs of the times, only a very few, probably between fifty and one hundred, will have obtained capital of their own and will operate on their own account or in company with others of financial means. A little larger member will have reached executive positions in organizations financed by others; the greater number of the geologists will be to the petroleum industry what the civil engineer is to construction or the mechanical engineer is to mechanics. He will be a moderately high classed employee furnishing data for the consideration of executives in many cases furnishing advice for their action in selecting and developing properties. The future geologist's portion will be that of an engineer. His limitations will be known and understood and he will not be paid as if he had some mysterious information which, when applied, would result in the flow of great streams of oil from the ground, but he will be paid a little more than the average engineering rate because this is a speculative business and that class of business always pays its workers more than normal business pays.

"Are there geologists[1] enough now?" There are enough, but probably not too many real geologists, but there are probably plenty practicing the profession and with the great number pouring out of the colleges without practical experience, these practitioners will be greatly crowded. College training alone does not make a geologist. That assumption by oil men has been one of the greatest detriments to the profession. The

most marked failures, the most bitter experiences of disappointed financiers have come from this assumption. There must be native ability, then college training, then long hard field training and a willingness and anxiety to work. The quacks are being slowly eliminated as a better knowledge of the ability of geologists is gained by investors and as the time of frenzied financing is passing.

Under prevailing conditions there are enough trained and experienced geologists to fill all the positions in the Mid-Continent field which the industry offers. Most of these geologists are young men; nearly all have from ten to thirty years of active life before them. There will be no shortage of petroleum geologists if all of the colleges in the United States continue to contribute from twenty-five to thirty thoroughly trained men per year, to fill the vacancies caused by those now in the work going to other work or to other departments of the petroleum industry.

American geologists now dominate the search for petroleum in foreign lands, but this field is to be a limited one and cannot be looked upon as offering a permanent attractive future to the young geologist. Just now there is an unusual demand because men native to the various lands have not been trained and experienced, but such training and experience will come in those lands, then the American who is a foreigner there will not be so much in demand. Probably one hundred geologists will be employed on the average in foreign lands after the next five years.

As one analyzes the factors of success by geologists who have achieved it, one factor stands out clearly. Permanent success in geology alone is based and maintained on field work, long hours, hard work, finding things in the open. Many office geologists fail to realize that the executive looks upon the geologist's work as an asset for the future, especially in ex-

[1] In this article the term geologist indicates a person who has had special college training in geology and sufficient practical field experience to make him capable of interpreting geology independently in a reliable trustworthy way. For the best interests of the profession and the individuals therein a geologist should have natural aptitude for the work, four years of college training, one to three years post graduate work and two to four years field experience with an experienced geologist.

ploration, and that when failure or hard times come, the executive finds in the geologist a man who can be dispensed with in his immediate trouble more easily than anyone else. The geologist who is not intimately connected with the oil business as such fails to understand this action because he looks into the future and does not understand this economic condition. The success of geologic work in the future will depend less upon field work alone. It will be the result of a combination of the field and office work, which will lead to a clear understanding of the relations of surface and subsurface structures, and the distribution of oil in relation to these structures. Many companies are employing geologists to collect and study samples from wells and this work will become increasingly valuable. During the next twenty-five years a few men highly trained in geology will have most desirable scientific positions, probably the average number of good places will not exceed five hundred. Perhaps one thousand more less well trained men will not be in so fortunate a position.

This is not a pessimistic outlook; it is the same view as must prevail in all branches of applied science. Those purely in the geologic profession and those contemplating it should realize that the meteoric portion of the science's course is passed; it is henceforth to take its place in constellation of sciences shining like one of them, but not with any peculiar brilliancy to make it wonderfully attractive.

THE PAST AND THE FUTURE

By H. B. Goodrich

At the present writing, early in June, it is quite the fashion in all branches of the oil industry to indulge in pessimistic thoughts. The tendency is not confined to the business end of the industry; financiers and oil producers feel the depression; but the petroleum geologist is also among the first to reflect the effects of low market conditions. So far is this true that sometimes there is a questioning of what the future may have in store for the scientist who is making the study of petroleum his life work.

While the younger members of the profession may reason-

ably feel some doubt on this point, those who have been a long time connected with oil matters have seen many similar periods which were perhaps even worse, and yet, in the face of low markets, and even apparent exhaustion of oil fields, the industry itself has survived and, often directly because of the efforts of the geologist, has grown. For instance, looking back many years, one may recall dire predictions that the railroads and other consumers in Texas would have to abandon the use of fuel oil because of the assumption that there was little likelihood of any more oil in Texas. This was at a time before the Mexico fields showed any large production. Further, while not in the fuel oil class, the fields of North Texas had not been seriously thought of. Further still the salt dome fields of the Gulf Coast of those days were in the same districts which are now being developed and were at that time supposed to be either condemned or practically exhausted.

All this is not intended for an argument that me may expect miracles in the future; that we may have a second Cushing field or any other spectacular, uncanny thing in the oil industry. We are engaged in the mining industry and deal with an elusive substance which we can not see until it is reduced to possession. Petroleum is hard to find and does not exist in unlimited quantities. Neither is it intended herein to predict the price of oil in the future. The writer has positive belief along all these lines but leaves such discussion for the statistician and for the technical papers.

The real desire herein is in one's feeble way to counteract misgivings and in a general manner to state that particularly within the last ten years there has been such progress in our work that it would be remarkable indeed if our knowledge and results are to stop at the point which we have now reached. It will be recalled that a few generations ago the mining geologist had not much reputation west of the Rockies. The "practical" mining man used to say that all it took to make a so-called "expert" was a pair of yellow legged boots and a wise look. That once popular joke became outlawed with time and the real engineer or geologist is recognized at his full value in hard rock mining. Our industry is younger than most other

mining and has had to pass through the same controversy with the self-termed "practical" man.

There are only a few of our members that can remember the Drake well which started things in the oil business; also I. C. White's first proposition of the anticlinal theory is somewhat before the time of most of us. However Dr. White, our guide and the pioneer of our profession, is still with us and still a young man and this shows what an infant petroleum geology is.

It is quite probable that Dr. White, whose footsteps we have followed, found it a large part of his work to educate the earlier oil men to a recognition of the sound basis of scientific geological reasoning as applied to oil well development. Certain it is that during the subsequent years the conscientious geologist has found similar difficulties. On the one hand has been the man who considers the geologist possessed of supernatural vision and gives him undue credit which it is impossible to live up to; on the other hand the skeptic who allows no good at all. The attaining of the happy medium, the reasoning client, has taken a great deal of education and self discipline on the part of the instructor. A little over ten years ago there were not many geologists in Oklahoma. Now there are probably five hundred men who have by their own exertions won their way to respected positions.

It is a very complicated history the last ten years of the oil business and one can but briefly touch on it.

In 1911 the world's oil production was 345,673,200 barrels. In 1920 it was 688,474,251 barrels. Of this, in 1911, the United States produced 220,449,391 barrels and in 1920 twice that amount, or 443,402,000 barrels. Statistics further show that in 1911 there were 152,000 producing wells in the United States and in 1920 this had increased to 258,600. These figures illustrate the growth in the infant industry for ten years and particularly the fact of supremacy of the United States in oil production during that time.

To go back to the year 1911, it may be well to summarize conditions particularly as they confronted the American operator and geologist. In that year the eastern fields were rather reduced. In the latter part of 1910, Caddo field in Louisiana

was in the limelight. The Gulf Coast was holding its own in production with some promising new fields. California had an over production, its annual production having been over 70,000,000 barrels. Oklahoma was second with 55,000,000 barrels. It will be remembered that the great Lakeview gusher in California had come in in March of 1910 and had flowed till about December of the same year, having yielded as high as 90,000 barrels per day. In the latter part of the year it was turning to water and its big time had apparently passed. Attention is also called to the fact that this Lakeview gusher was located in the Maricopa flats, in the country which had been looked on with disfavor by operators and possibly by some of the earlier geologists. In this lies a point which it is believed the geologist, as well as many practical oil men, should always regard, namely that it is unwise to accept as truth, preconceived ideas until these become actually proved facts. Operators would not at one time have ventured into the Maricopa flats.

In January, 1911, to go a little outside of United States territory, a wonderful discovery was reported from Mexico. Previously Mexico had shown as a potential producer by reason of large flowing wells of the Mexican Petroleum Company and the stupendous Dos Bocas oil volcano of the Lord Cowdray Company. The Potrero del Llano well of the Eagle Company in 1911 assisted materially in placing the Republic on the oil map.

Many of the members of this Association are qualified to state with authority what connection geologic advice had with the location of the Potrero del Llano well. At any rate there is remembrance of a conversation with Dr. C. Willard Hayes some time later. In this the writer of this paper, by influence only and certainly not by reason of any boastful claim of Dr. Hayes's, which would have been foreign to his character, came to the belief that he had sized up the oil possibilities in advance. Furthermore that if he was not actually to be credited with discovery honor he at least had assisted by professional advice and encouragement at a time when it was much needed and that not many days before the magnitude of the well startled the oil world.

This Mexican matter is, however, getting into the province of the well known members of this Association mentioned above who were with and after Dr. Hayes in the progress of petroleum geology in the Republic up to its present high standing.

In the United States the oil business did not in 1910 to 1911 particularly favor the oil geologist. However reference should be made to a paper by Raymond S. Blatchley which appeared in The Oil and Gas Journal, in December 15, 1910, "A New Branch of Engineering, Petroleum Mining." In this the principles of conversation were recommended and it is asserted the "belief is arising that geologists are of value in the oil business."

All of the above few notes regarding the past history of the oil business are given simply for comparison with conditions of the present day. At that time the Cushing field was not known, while Petrolia in North Texas had reported a few wells, there were only a few insignificant producers north of the Red River and in the "Red Beds" country of Oklahoma.[1] In fact the "Red Beds" country was not at all recognized, nor was its future, as an oil country, hardly imagined. This has come within the last eight years and such fields as Fox, Walters, Hewitt, North and South Duncan, Velma, and Robertson are directly attributed to geology.

The main point which impresses one is that the entire oil business is one of constant progress. Methods of drilling have been improved upon. For example, during Spindletop times in Texas, a depth of 2,000 feet with a rotary rig was considered very near the limit Now, rotary rigs with improvements are capable of drilling economically in the proper territory, to a depth of over 4,000 feet. Production methods also have been vastly improved. Fields in California threatened by water incursion have been rescued by proper engineering methods of water shutoff. This progress along the mechanical and operating ends has been and is being equalled by that on the scientific side. In all branches of our industry we are gaining by the experience of the past and this applies fully as

[1]These wells were in the Wheeler field, discovered by Mr. Goodrich.—The Editor.

much to geologic knowledge as to any other. It seems that the geologist's work is broader than it used to be regarded. Nowadays it is not merely required of a geologist that he should be able to map an anticline and draw structural contours, but that he should be constantly in touch with ever changing situations, general and particular. It is a very important part of his work to locate new propositions and he should have the courage of his convictions, if any wildcat proposition looks good to him, to recommend the development of it. This is because the geologist should aid constructively in making money for his client or employer, quite as much as to save his client from useless expenditure. But the location of new propositions is by no means all of a geologist's work. The science is still an inexact one, but its inexactness has been made less by constant observation of wells, each one of which is different from every other and only has some few family traits in common. This, it appears, is in the line of work of geological engineering which has come to the forefront within the last few years. By the increase of data given by drilled wells, dry holes and producers, the geologist is now ready to make subsurface maps which are of extremely greater value than the surface geologic maps which had to serve before experience gave any information beyond the depth of human vision. By the scientific correlation of observed facts by the trained geologist, many old theories have been destroyed and the latent truths have been discovered.

The production figures quoted above show the greater importance of the United States over all other nations in oil production. It is a fact that we are preeminent among the nations in the manufacture of oil well machinery and apparatus. It cannot be doubted that our drilling rigs and apparatus are superior and are even adopted in preference to their own over our northern border in Canada. Our methods have become better because of our having had many difficulties to overcome in drilling. For instance, in the California fields of loose formations, methods to overcome the peculiar heaving sand and deep well conditions have been evolved. Again what is true of the mechanical side is true of the scientific engineering part. We have the biggest fields in our own territory

or near our border. We have the opportunity for practice and for application and testing out of theories to meet all conditions.

We have the largest production in the world. We have the greatest number of wells. We have all kinds of conditions to meet. It has been up to the geologist to know these conditions. He has had the opportunity to study and has made the best of it, therefore the American petroleum geologist should be, and is the better prepared by actual training and by actual contact with oil itself than the geologist from any other country however great a student the latter may be. This does not imply that the American geologist should in any way disregard the occurrences of oil or the experience of other countries, but it is believed that he has the preliminary training sufficient to attain prominence anywhere in the world, provided he does as he has done, namely study the proposition open-mindedly and then make his recommendation without fear. His work does not stop with the beginning of a well located on his recommendation. It continues throughout the drilling of the first well, subsequent wells, through the decline of a field and to its ultimate exhaustion. In all stages of the process from the beginning to the end of a lease or field, he is of value to the industry. This is because he has duly studied the oil proposition with all of the advantages or most of the advantages that were offered in the world and his school has been one of hard practical knocks.

The application of engineering supported by observed facts tends to make geology an exact science. The result is that the petroleum geologist's conclusions are of distinct value to the operator. We have not reached the end by any means. With more wells drilled, all shore lines and subsurface structures extending over wider areas can and will be definitely mapped. The geologist's percentage of success is always increasing. Old theories may be discarded by reason of the newly discovered facts and for this very reason those now entering the science have much better opportunities than the fellows of the past who had to work on much more meager data, but built good foundations.

each case possible; and that the results obtained depend directly upon the intensive and extensive limits of the investigation.

The past influence of geology in the Eastern fields is clearly inferior to its influence in the Mid-Continent region. This is due mainly to the misapprehension on the part of the producers of the limits of the science and the capacity of the geologist, inability to distinguish between geologist and "alleged geologist." The future standing of the commercial oil geologist and the future measure of the results that will be obtained by his efforts, depends mainly on the recognition by himself and his client of these limitations, as well as the attitude of the geologist in accepting and undertaking only investigations which fall within them.

The present low market and the resultant shrinkage in the value of leases offer an exceptional opportunity to the producer and company who are in position to continue detailed Eastern investigations as a basis for rearrangement of their acreage against the return in the future of a normal market for the product.

DEVELOPMENT OF PETROLEUM GEOLOGY IN CALIFORNIA

By W. R. Hamilton

The early California oil developments were made without the advice of geologists, the discoveries having in nearly all cases been the results of drilling in close proximity to seepages. Prior to the discovery of the Kern River field in 1899, the production of the state was unimportant and the industry was not taken very seriously. Following Kern River, important discoveries were made at Coalinga, McKittrick, Santa Maria and Midway and, with the development of a market for fuel oil, the industry rapidly expanded.

Probably the first geologist who attempted a comprehensive study of the California oil fields was George Homans Eldridge, of the U. S. Geological Survey, who in 1901 began an investigation of all the known occurrences of oil in the state and had in preparation a monograph covering all the

fields of the state. Ill health prevented the completion of the work and after his death, in 1905, Ralph Arnold was assigned the task of preparing his unfinished manuscript for publication. The results were incorporated in Bulletin Number 309 which covered the fields of Los Angeles and Ventura counties and which was published in 1907. This publication was followed shortly by other valuable Geological Survey publications by Arnold, Robert Anderson and others, covering Coalinga, McKittrick, Midway-Sunset and Santa Maria fields. The general excellence of these contributions made them an excellent foundation for the more intensive study later made by geologists in private employ.

Prior to the publication of the Eldridge bulletin the Southern Pacific Railroad, which had extensive holdings in the San Joaquin Valley fields and which was probably the first California oil producing concern to realize the value of geological work, had begun a careful study of the San Joaquin Valley deposits. The Company had vast holdings under its land grant and since it was not in the market for additional holdings, the work of its geological staff was primarily for the purpose of determining the value of its holdings and of aiding in its operations and therefore did not reach the attention of other oil operators However, the pioneer work of F. M. Anderson was of great benefit to later geologists as the Southern Pacific Company always allowed its geologists to publish the results of their field investigations. The Santa Fe Railroad also made early use of geological advice, having acquired valuable holdings in the San Joaquin Valley fields upon advice of its geologist, H. B. Goodrich.

It was the appearance of the Geological Survey bulletins which made the oil operators realize the value of geology in connection with wildcatting and development and, within a short time, geologists were freely employed by Associated, Union and Standard Oil companies, and later by nearly all operators of magnitude. The following fields were later developed and their discoveries are properly to be credited to the work of geologists: Beuna Vista Hills and Elk Hills fields of Kern County; Richfield and Montebello and Signal Hill fields of Los Angeles County; Huntington Beach of Orange

County; and Shiells Canyon, Santa Susana, South Mountain and Ventura Canyon fields of Ventura County. These fields are at the present time producing about one-third of the production of the state. During that same period three important fields were discovered which are not credited to geologists: Cat Canyon of Santa Barbara County; and Bell Ridge and Lost Hills fields of Kern County. Of the total production of the state, about one-twenty fifth comes from these three fields.

The areal extent of the California fields is small and the regions with oil possibilities are restricted. While the above record is impressive, it is not in exploration work that the geologists have proven of greatest importance to the California producers. In many of the fields the structure is rather complex with faults and unconformities not uncommon and, as at McKittrick, even overturned anticlines are known. The oil sands are not often continuous for more than a short distance and occur as lenses in well defined zones. Water is often encountered in close proximity above or below the oil and gas bearing sands and a careful study is necessary to protect the sands from water. Many of the early fields were seriously affected by water encroachment due to setting casing at incorrect depths or to continuing drilling to too great depth. Besides using geologists whenever wildcatting, every California oil company of prominence has its geological staff which devotes its time to problems directly affecting operations. The work is both constructive and protective; constructive in determining where the best production may be obtained and protective in preventing damage to the oil sands from water, the greatest bane of the oil fields In the latter work the operations of the State through its State Mining Bureau is worthy of mention. Geologists of the Bureau, working under the authority of the Conservative law, have done incalculable good in protecting the oil deposits of the California fields. Their work was at first resented by operators who did not understand it but its value is now universally recognized and the State Mining Bureau has convinced the California operators that geology is essential to their oil operations. The Bureau publishes monthly a "Summary of operations in the California

In the foregoing a distinction is made between the operator and the petroleum geologist. Is there anything to prevent the geologist himself from becoming the owner and successful operator of properties? Professional ethics of the student perhaps; but many of our most successful members have answered the question with decided negative and are consultants for themselves and not for others.

COMMERCIAL OIL GEOLOGY EAST OF THE MISSISSIPPI

By Ralph W. Richards

The rational basis of oil geology was enunciated by Dr. I. C. White[1] after his re-discovery of the "Anticlinal Theory" in 1882. Since that time many promising gas and oil bearing areas have been outlined in the various publications of the U. S. Geological Survey, and the Surveys of the States of Illinois, Kentucky, Ohio, and Pennsylvania. In spite of the often heard general criticism that many of these reports have been "post mortem" it may be said that often so long a time intervened between the suggestion and the subsequent tests, that even when favorable results have been obtained, credit failed to be given the source.

These organizations have performed a further service in training men for subsequent professional activities in commercial work, and especial mention may be made at this time of the Federal Survey, which as far as is known to the writer, lost by resignation its first man to commercial oil geology in W. T. Griswold in 1907. In 1908 F. G. Clapp left the Geologic Division of the same organization and started a commercial consulting practice in Pittsburgh, and since that time there has been a steady flow of trained scientific workers into this economic branch of the profession, among whom may be mentioned L. C. Glenn, M. L. Fuller, J. H. Gardner, M. J. Munn, C. W. Washburne, W. C. Phalen, J. H. Hance, and C. A. Bonine. These men and others have contributed to developments in the Appalachian region.

[1]Science, June 26, 1885, vol. 6.

The part which geology has played in the development of oil and gas East of the Mississippi up to 1917 has been admirably described by Myron L. Fuller in an article in Bulletin of the Geological Society of America[2], and little can be said in extension except to summarize and comment on the results since that time.

Fuller recognized three periods:

"I. Period of unconscious application of certain geologic factors. 1859-1888.

II. Period of application of anticlinal principle. 1888-1900.

III. Period of intensive application of geology. 1900-1916."

The years 1917-1920 represent a continuation of the last period, and while it is not possible to give exact figures as to the number of companies maintaining geologic departments, and the number of consulting geologists who have undertaken occasional commissions in the region East of the Mississippi, it can confidently be stated that an unusual amount of geological work has been done in the district during these years, and results have been obtained in the extension of old pools, the discovery of new pools, and the development of deeper sands along the lines suggested by Fuller, which are shown in the gradual increase of production for the Appalachian fields for the several years as follows.

1917	24.9 million barrels
1918	25.8 million barrels
1919	29.2 million barrels
1920	30.5 million barrels

While it may be conservatively estimated that possibly at least $10,000,000 worth of this additional oil was obtained through applied geology, yet it must be admitted that other factors assisted in building up this increase in production, i. e., cleaning out of old wells, increased care to prevent wastage, and more careful attention to all production details owing to the enhanced value of the product. The cost of this extremely practical application of science cannot well have ex-

[2]Appalachian oil field, Bull. Geol. Soc. Am., vol. 28, pp. 617-654, 1917.

ceeded a tithe of the immediate realization, throwing out of consideration the attendant future returns.

It is also true that many attempts to locate new pools by structural surveys have failed owing to:

(1) Absence of saturated reservoir rocks,

(2) Failure of sub-surface structure to synchronize with surface structure because of unconformities, and in many cases lack of sufficient well-log data to permit proper determination of convergence,

(3) Incorrect interpretation of structural conditions incurred through errors (*a*) in correlation of beds, or (*b*) incorrect determination of elevations and attitude of beds. However, sufficiently favorable results have been obtained to justify the statement that all the money which has been spent by the various oil companies along well considered geologic lines has yielded satisfactory results.

In certain of the Eastern pools it has been more clearly shown that the geologic structures in which the rocks have either been deposited or deformed play but a minor part in the localization of the oil and gas while rock texture, either depositional or induced, is the predominating influence, and yet in other cases accumulation follows structure as closely as in the Mid-Continent region, and even in textural reservoirs gravitational segregation of gas, oil, and water is evident.

The importance of sub-surface work has become clearly established, both in those districts where rock texture is the main accumulation factor, and elsewhere since it represents the only method by which the difficulties introduced by unconformities can be overcome.

Too much of the so-called geologic work in the East has consisted of sending the geologist or "alleged geologist" to "look over" a tract or acreage and requiring a report based upon insufficient data. In view of this fact it is remarkable that geology has accomplished as much as it has. Many of the oil companies are not yet aware that petroleum geology requires in the first place detailed mapping of rock outcrops, detailed study of the stratigraphic section, and correlation and study of all available well logs, not only on the acreage in question, but including as much of the surrounding territory as is in

oil fields" which is distributed free to all who are interested.

The intensive geological work in California began shortly after that in the Mid-Continent, but unlike the work in the latter district it is largely connected with technologic problems. It is probable that there are about one-third as many geologists in the California field as in the Mid-Continent.

THE PETROLEUM GEOLOGIST IN MEXICO

By Burton Hartley

In estimating the value of a science it is no more fair to consider it as an abstract quantity than it is to measure it only by the actual returns when applied to a specific industry. Yet it is this two-fold viewpoint that has caused the division of the oil fraternity into those who can realize the aid rendered the operator by a geologist and those who can see no good in geology, pointing out the many negative results obtained.

To make a contribution to science it is not necessary to develop an entirely new thesis—to discover something previously unknown, or even to rush into print in order to be merely the first to record something. And above all it is not necessary to publish one's results at all in order to have accomplished something. Rather the mere accomplishment is the contribution to science if such accomplishment is recognized by others in the same line of industry. Perhaps a false idea has been given to the younger generation of geologists by the mass of literature bearing the sole title "Contributions," etc.

The petroleum geologist in Mexico has accomplished much, and yet the record of these accomplishments is written down mainly in the operating records of companies interested in the Mexican fields. The literature on the oil regions of Mexico is limited, primarily because the character of the geologists' engagement renders it so, and secondarily because of the character of the work which is not always pure applied science, but is measured in terms of results obtained and does not warrant publication

Let us take up the first case. Prior to the entry of the petroleum geologist a small amount of regional work had been done by certain Mexican, English, French and German geologists but their work falls into the class of pure science and

was not connected with the oil industry. Probably the first oil work was undertaken in 1900-01 by W. H. Dalton, the English geologist for the Pearson syndicate then constructing the Ferrocarril Nacional de Tehuantepec. From 1907 to 1909 various other English and Swiss geologists made limited examinations for the same or affiliated syndicates. Obviously the results of their work were never made public. The first description of the oil regions by Villarello appeared about 1908.

About this time the influx of American geologists commenced and has continued and increased till today. The Pearson syndicate turned over their exploration to an American, the late Dr. C. W. Hayes, in 1908, and under his direction and that of his successors the major portion of the oil regions of the east coast has been studied in detail. To date practically none of the results of this work has been made public beyond that shown in the continually increasing revenue of the Mexican Eagle Oil Co.

If the discovery of oil in Derbyshire, England, was an accomplishment this work certainly was. And yet, Mr. E. L. Ickes, the man whose field work was instrumental in locating the Derbyshire well was one of the mainstays of the Pearson staff in Mexico for several years. Should his work in Mexico be ignored because of the lack of notoriety obtained in contrast with the wide publicity given the Derbyshire discovery? Dr. Hayes is largely credited with the discovery of the famous Potrero del Llano field and E. L. DeGolyer is mainly responsible for the Nos Naranjos field brought in at a time this latter area was not highly regarded by his British employers. Similarly, in the files of many of the producing companies there are highly favorable reports upon the major portion of the present producing districts. One might ask if the discovery of these fields was not directly attributable to seepages. Perhaps so, but for every discovery well drilled near a seepage there are perhaps five failures to be set against the false lure of the "ojos de chapapote."

In 1910 Jeffreys completed a report upon the geology of eastern Mexico covering the major portion of the present oil district. While his report has never been published, it has

been obtainable and has served as the basis of much that has been done and written by others. Many of his formation names persist today, no mean reward when considering the limitations under which he worked.

In 1908 the Southern Pacific Co. commenced an examination of the country beginning at the Texas line. With Prof. W. F. Cummins in charge and under the direction of Dr. E. T. Dumble their geologists covered practically the entire area. Prof. Cummins is directly responsible for the discovery of the Panuco field in 1910. In 1911 Dr. Dumble commenced publishing a meager portion of the results of this work and the early ideas and conceptions of the problems of the country therein set forth has persisted and is accepted today.

So much for the pioneers who were followed by ever increasing numbers of geologists till today there is not a large producing organization in Mexico which has not called upon science for its conclusions. To attempt to single out from this number those who have particular claim to accomplishment would only be to neglect others just as deserving. Not a word need be said about the hardships under which these men worked, that was all in a day's work and expected of the type of man sent into that country.

To pass to the accomplishments not directly attributable to pure science one can touch but briefly, too many receive but scant attention or credit and are known only among the parties concerned.

Several such accomplishments come to the writer's mind. If memory serves correctly it was in 1913 that Belt first voiced the opinion about the depth of the salt water table, an opinion that is yet to be disproven, even the trade journals of today carry the sea level depths of completion. In 1913 the geologists of the Mexican Eagle company undertook some investigations regarding oil well temperatures. The results obtained when combined with the experience of the producing department and other operators enabled a much more efficient handling of the fatal salt water problem which cropped up in 1919. To digress a moment, the taking of well temperatures was a new experience to most drillers and very shortly became a new alibi. The drilling reports of the company soon

began to show everything from broken cables to burnt out boilers as due to too high temperatures.

Then too, one cannot overestimate the value of the work accomplished by the subsurface geologist and the paleontologist in solving stratigraphic problems leading to condemnation of areas where the oil reservoir is beyond reach of the drill.

The writer has but touched upon the service of the geologist in Mexico. In these days when propaganda is belching forth from the tariff and antitariff advocates and from the men with stock market values to maintain how much more in the way of service and accomplishment could be done if the geologist was untrammeled in expression.

In sum the industry owes a debt to the fraternity for service rendered and results achieved that cannot be glossed over by pointing out the lack of indestructible record of accomplishment be it in new theory evolved or new oil resources unearthed.

EXPERIMENTAL PETROLEUM GEOLOGY

By A. W. McCoy

Petroleum geology in the past has been largely a study of structural observations in the field, with various amounts of philosophic and scientific theorizing. Considerable experimental data has been offered to promote or establish certain possibilities in reference to the origin of petroleum, while a comparatively small amount of experimental work has been accomplished relative to the theories of accumulation.

The nature of the science is such that convincing experimental arguments are difficult to construct. Accumulations of petroleum are buried under hundreds of feet of sediments so that only meager data from well records are accessible for the complete analysis of origin and accumulation. Factors of time and distance, which no doubt are of vital importance, are impossible to duplicate by laboratory methods.

F. W. Clarke* in summarizing the evidence of experimental classics on the synthesis and origin of petroleum suggests that "nearly all of the proposed theories to account for the origin

*U. S. Geol. Surv., Bull. 616, 1916, p. 737.

of petroleum embody some elements of truth," but later adds that "the organic origin of petroleum seems to be the best supported by the eologic relations of the hydrocarbons which are found in large quantities only in rocks of sedimentary character."

The same may be said of the experimental work concerning the accumulation of petroleum. The evidence as offered by M. A. Daly, Johnson, Van Mills, and the author all contain certain elements of truth even though the conclusions reached by the experiments are decidedly different.

For instance, Van Mills in working from the recovery point of view, assuming comparatively rapid movement of water in porous sands, shows striking conditions in favor of the gravitational or hydraulic anticlinal theory; while the author assuming practically static conditions of saline ground waters, shows a method of accumulation with fine grained sands and muds in harmony with detailed structural field relations previously observed.

The truth, however, can only be ascertained when the exact conditions are known and the phenomena analysed by correct physical laws. Exact conditions are out of the question for the present, and future experimental workers on the problems of accumulation should search thoroughly for the abundance of detailed field data in order to start with conditions nearest the true facts.

For conclusive results this is not the work of either the ordinary field or laboratory geologist, but more for the men who are well versed in the science of physics and who are thoroughly familiar with detailed and comprehensive knowledge of oil fields and regional geology. Best results can not be expected from advanced students with little field experience, although any of us may be benefited by experimental attempts.

Experimental work on problems of accumulation will always remain secondary to field observation so far as the geologist is concerned. To a few men who are well qualified, this branch of endeavor offers wonderfully opportunities; but the average geologist is neither qualified nor able to give the necessary time to such study.

Oil shale experimental work is another field of vast research which affords possibilities to the young men of the science. The work of David White, Winchester, Davis, Trager, and others can be carried on in special branches of innumerable problems.

In the future, experimental work will unquestionably develop better scientific men although only a few of the present day geologists have the chance to attempt such lines of investigation. These fortunate individuals who are well qualified will become a great factor in clarifying the analysis of petroleum geologic phenomena.

In the meantime it behooves us all to submit our suggestions with the attitude of discussion, considering always that there may be another solution to the problem which answers equally as well as our own and is less entangled by faulty assumptions.

THE HEALDTON FIELD, OKLAHOMA

BY JOHN G. BARTRAM AND LOUIS ROARK.*

INTRODUCTION

The structure of the Healdton field in Carter County, Oklahoma, has been more or less of a problem to all interested in that field, because the producing sands are so lenticular and irregular that correlations are very difficult to make. The Roxana Petroleum Corporation has been especially interested in the structure of the field, and has spent considerable time and money in working it out as correctly as possible in order to have all information available concerning their properties.

MODE OF STUDY

As almost no knowledge of the subsurface structure had been gained by drawing scattered cross-sections through the field, a method that is practical in most Oklahoma fields, it was decided to plot the logs of almost all the wells on parallel north-south cross-sections, thus making all the data available in graphic form. Accordingly ninety-four cross sections on tracing cloth were drawn across the field. From these cross-sections the structure map was made. Correlation lines were first drawn on the base of the Permian water sands and on the top of the Pennsylvanian oil sands, the two lines being apparently conformable and parallel, and then to locate and eradicate irregularities caused by errors in the logs, or by local thinning or thickening of the sands, the transparent tracings were superimposed one upon another to see how closely the correlations agreed on adjacent cross-sections. The writers were thus able to draw on the top of the Pennsylvanian oil sands generalized lines, which it is believed show the main structure of the field, as depicted on the enclosed structure map (Fig. 1). It should be remembered, however, that the sands are so irregular that their exact depth in any well cannot be predicted as accurately from this map, as they can be on most subsurface maps in Oklahoma. The great irregularity of these sands is strikingly

*Published by permission of the Roxana Petroleum Corporation.

illustrated by a few wells, that found almost no sand and are therefore dry in the midst of productive territory and near good oil wells.

STRATIGRAPHY

The surface rocks in the Healdton field are Permian "Red Beds," beneath which are Pennsylvanian strata, which in turn rest upon Ordovician rocks with a large unconformity as described by Powers[1].

Permian: The undifferentiated "Red Beds" of the Permian, which cover this field to a depth of 200 to 800 feet, consist of alternating beds of red and gray shale, and brown, white, and red sandstones. Beyond the edges of the field the "Red Beds" extend to even greater depths. Most of the sandstones of the "Red Beds," particularly the bottom ones, contain fresh water, and the base of the water sands is arbitrarily called the base of the Permian, for beneath it is a thick blue shale that is considered to be of Pennsylvanian age. The cross-sections show that the base of the Permian is parallel with the tops of the oil sands in the Pennsylvanian and prove that there is not an angular unconformity between the Permian and Pennsylvanian in the Healdton field. If there is an uncomformity between these two systems here, it must be a disconformity or break in sedimentation.

Pennsylvanian: The Permian is underlain by blue shale, sandstones, thin limestones and sandy shales of Pennsylvanian age, and it is from these strata that the oil of the Healdton field is produced. In the field about 500 to 1,500 feet of these rocks are found by wells before the big unconformity between the Pennsylvanian and older rocks is reached. The authors have been unable to determine to what part of the Pennsylvanian these shales, sandstones, and limestones belong, but believe that they occur close to the top of the formation. Immediately underlying the basal Permian water sand is a body of Pennsylvanian blue shale, 300 to 450 feet in thickness. In this shale there are some scattered, irregular lenses of sandstone that carry oil and gas. Beneath this shale is the main body of oil

[1]Powers, Sidney, The Healdton Oil Field, Oklahoma, Economic Geology, vol. 12, No. 7, pp. 594-606, 1917; Age of the Oil in Southern Oklahoma fields, Trans. Am. Inst. Min. Engrs., vol 59, pp. 564-575, 1918.

and gas sands in the Healdton field, called in this article the *Healdton oil sand zone.* This producing zone is from 250 to 350 feet thick and consists of from two to five sandstones interbedded with shales and limestones. Beneath this Healdton zone is a body of Pennsylvanian rocks varying in thickness from 50 to 500 feet and consisting of blue shales, oil, gas, and water sands, and thin limestones. This zone thickens rapidly away from the field, as the unconformity decreases and more and more of the Pennsylvanian beds appear.

The lower part of the Pennsylvanian has never been recognized in the Healdton field to the writers' knowledge. The Franks conglomerate, which many geologists do not regard as one definite formation, but rather as a basal conglomerate on the unconformity, has been found in at least one well, Roxana Petroleum Corporation Keck No. 13, in sec. 5 T. 45, R. 3 W., found gravel from 1,082-1,092 feet which J. W. Merritt, who was present when the well was drilled, identified as Franks conglomerate. He stated that, "This gravel was made up of extremely well-rounded, hard limestone pebbles up to an inch in diameter, undoubtedly eroded from the Viola limestone." It is very probable that scattered deposits of conglomerate have been found by wells that passed through the unconformity in other parts of the field, but no record of such deposits is shown in the logs.

Unconformity below the Pennsylvanian: Beneath the Pennsylvanian there is a very large angular unconformity, so that the Pennsylvanian beds rest upon upturned rocks as old as the Ordovician. Quite a few wells have drilled through the Pennsylvanian into these older rocks, and it is believed that the Viola, Simpson, and Arbuckle formations have been penetrated. Wells may have been drilled into still other formations beneath the unconformity, but if so they have not yet been identified.

Ordovician rocks: The thickness and character of the Ordovician rocks cannot be told very accurately in the Healdton field, but in the Arbuckle mountains to the north, the Viola is a continuous, but slightly variable deposit of limestone 500 to 750 feet thick, and the Simpson beneath it ranges from 1,200

shale, sandy shale, limestone, and sandstone. The Viola has been recognized from fragments of trilobites in a number of wells in the field, and the Simpson formation identified also by fossils, produces oil in two wells at a depth of 2,700 feet.

STRUCTURE

Folds: The main Healdton field is an elongated dome, about

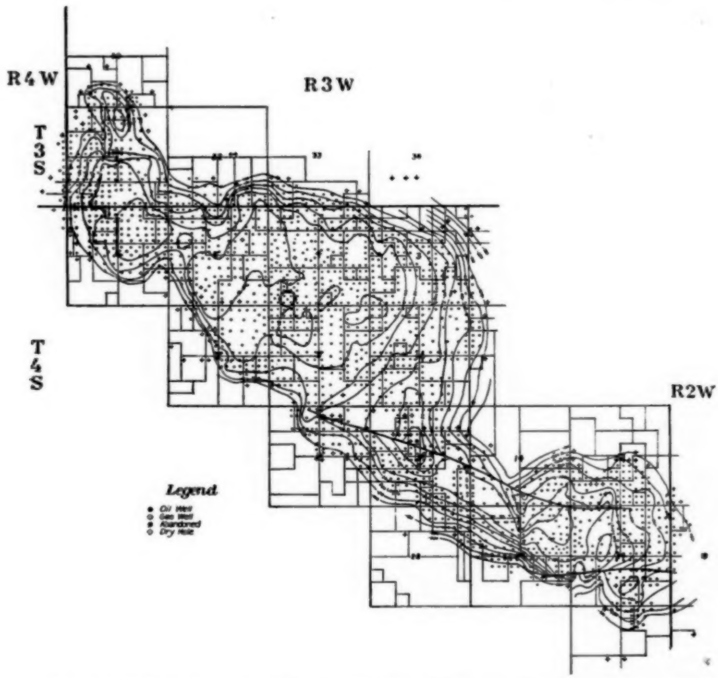

Fig. 1. Subsurface structure contour map of the Healdton field, Oklahoma, datum top of Healdton sand zone, contour interval 50 feet.

four miles long, extending in a northwest-southeast direction, with a broad fairly flat top but dipping off quite steeply on all sides. At its widest part in secs. 3 and 9 the field is two miles wide, more than half of this being on top of the fold and fairly flat. In the west half of sec. 5 the structure is narrowed by two synclines that cut in from either side, but in sec. 6, T. 4 S., R.

to 2,000 feet in thickness and consists of alternating beds of 3 W., and in sec. 31, T. 3 S., R. 3 W., it broadens out somewhat with a hook that extends straight north. The high part of the structure in the northern part of sec. 31 is largely due to a considerable thickening of the Healdton sand body in that place. The closure on the main structure amounts to at least 300 feet and probably more if the contours are extended beyond the limits of oil production. On top of the structure the highest points are in secs. 5, 6 and 9. The Healdton sands of Pennsylvanian age that comprise the main field were deposited around and over a core of folded older rocks, principally limestones, and were then folded with the older rocks some time after the deposition of the lower part of the Permian.

Faults: The presence of the "Southeast Extension" of the Healdton field is due to a large normal fault that cuts across the southeast side of the main anticline in secs. 15 and 16. The fault with as much as 450 feet vertical displacement has lifted the sands on its south or upthrow side higher than they are on top of the anticline. The dip to the south away from this fault is quite steep amounting in sec. 23 to as much as 550 feet in ¾ mile. On its west end in sec. 16 the fault apparently fades into the fold that forms the south edge of the field. From sec. 16 the fault extends east through secs. 15, 14, and the corner of sec. 23 with two high points on its south side, one in sec. 15, and one in secs. 14 and 23. From there it extends into the northeast quarter of sec. 24 where it fades into an anticlinal fold. This fold in sec. 24 is broken by another normal fault, which crosses the south half of the section and fades out in sec. 23 on the west. To the east it runs into sec. 19, T. 4 S., 2 W., where it probably fades out, although the lack of data makes this uncertain. The upthrow side of this fault is to the north with a vertical displacement of as much as 200 feet. As the two faults have their downthrow on different sides, they leave the north half of sec. 24 as the fault horst. In sec. 14, north of the large fault and between the "Southeast Extension" and the main field, there is a deep syncline that carries the sands down to considerable depths.

RELATION OF STRUCTURE TO PRODUCTION

It is interesting to note the number of dry holes and gas wells that lie along the larger fault in secs. 15 and 16. The location of the fault can easily be traced on any production map of the field because of the number of deep dry holes in the fault zone. When the wells were first drilled, there were a large number of gas wells in sec. 15 on the high areas on both sides of the fault, but they are not noticeable on the map, since most of them now produce oil. On several of the leases in the south half of sec. 15 the best oil production, or rather practically all the production is on the highest point adjoining the fault. There is no question but that the large fault has a normal throw because the fault can be shown to exist in the older limestones several hundred feet below the top of the Healdton sand zone. The fault trace is farther north in the older rocks than in the Healdton sands, and the downthrow is to the north.

Although the large fault fades out in sec. 16, the writers believe that there may be one or more faults on the south edge of the field in secs. 6 and 8. The field stops rather abruptly there, and the water level in the sands is very much higher than it is on the northern edge of the field. Water is found at least 100 feet higher on the south edge of the Roxana Petroleum Corporation Horton lease in sec. 6 than it is on the northern edge of secs. 30 and 31. The presence of such a fault or faults cannot be proven with the information that is available from the dry holes along the edge of the field. The straight south edge of the field in secs. 16, 22 and 23 is plainly caused by the steep south dip of the sands.

While the writers believe that part of the dip on the sides of the field may be due to the settling and sagging of the Pennsylvanian sediments about the core of older rocks, it is their opinion that the structure is largely due to deformative folding. The presence of two large faults and the steep dips away from the faults prove this conclusion.

THE TIME FACTOR IN THE ACCUMULATION OF OIL AND GAS

BY ROSWELL H. JOHNSON*

The study of the origin and accumulation of petroleum has very naturally been analytic so that we have had a variety of studies of its several features. As the process is a continuous one, passing through a long period of time, it has seemed to me desirable to try to string together the several elements which have come to be seriously considered in their time relationship, in order to see if something of moment might not arise from that arrangement.

Starting with organic remains as the original source the first time feature is the necessity of slow decomposition. The most essential requisite is the presence of water containing either salt or the combination of qualities found in the water of stagnant swamps. The second most important feature is the existence of cellulose and this mainly as the fibro-vascular bundles of the higher plants and spore exines, resins, and waxes, As a third factor the presence of the floating bubble of oil found in diatoms has been suggested. This bubble would presumably outlast the protoplasm, but we do not yet have definite evidence that such bubbles would be brought to the bottom by the weight of the exo-skeleton which also outlasts the protoplasm. Unless the exo-skeleton not only cages the presisting drop, but weights it down fully to the bottom, the diatoms would seem to be impotent, but if that is the case their role must be greatly superior to that of the foraminifera, which would seem to offer relatively slight opportunity for deposition of organic matter because of their very soft unstable protoplasm.

Unless we can look to the diatom it seems difficult to believe that there are important organic constituents in deep sea deposits when they are eventually covered.

*Professor of oil and gas production, University of Pittsburgh, and member of firm of Johnson, Huntley & Somers, Pittsburgh, Pa.

The primitive nature of the plants in the Cambrian is the probable cause of its dearth of hydrocarbons, as the plants of that time were not supplied with fibro-vascular bundles, nor equipped in any important degree with highly resistant spore exines, waxes, and resins, at least of the latter resistant type. The Ordovician and Silurian constitute transitional periods still deficient in their hydrocarbon content, though increasing, and with plants so poorly equipped with parts that resist early decomposition that no coals have yet been found.

Since in any event the organic material is of so little moment unless not far removed from a sandstone (or other reservoir) we are obliged to turn attention especially to the lagoon deposits, for it is especially these that have sand brought directly against muds which are rich in the detritus of cellulose-bearing plants lying in salt water mud, since off shore vegetation consists to a much less extent of the higher plants, such as eel grass, rushes, etc.

Sand bodies as we see them recently formed are of two sorts—deposits which would constitute sheet sands substantially as they exist in the event of a subsiding shore, and bodies which could not persist under those circumstances (such as sand dunes, sand bars, and the like) which would be reworked by the waves and flattened out into the usual sand sheet.

As petroleum geologists we are especially interested in the local thickening of sand sheets where we find wells of greater yield if water does not occupy the extra thickness gained. Such nodes (I suggest this term as preferable to lense, as lense should be confined to bodies especially like a bi-convex lense, whereas the thing here described is a thicker portion of a sand body which is in general sheet-like), such nodes have escaped the usual reworking into uniform sheets. Eight methods are here suggested to explain deposition of sand below the level which is subject to subsequent reworking by waves. This level is between the zone of destruction and what we shall call the protected zone.

First, if stream beds are present and if there are stream sands to be covered they become a part of the sand body as a whole. This is the usual result of a marine transgression.

Second, a sandy hook extends out into deep water at some angle in the shore, and thus dumps sand at the end into the protected zone which will not later be reworked. Chatham, Martha's Vineyard, and Sandy Hook are examples.

Third, the tombolo or sand spit which connects nearby islands to one another or to the mainland. This likewise deposits sand in the protected zone. Example—Nahant and Nantasket.

Fourth, points of the type of Pt. Pelee, Ontario, where a conflict of wave or current builds out an A-shaped point into deep water and there accomplishes the dumping of beach sand into the protected zone.

Fifth, points like Fire Island south of Long Island which are shingling hooks started at the points where guts occur through which the tide sweeps in and out to the lagoon behind, or as at Presque Isle, Erie, Pa., started by the outflow of a stream. By their overlapping growth they deposit sand in the protected zone.

Sixth, the scour of current, howsoever formed, may convert a deposit in the protected zone from a sandy mud into a sand.

Seventh, an unusual storm may make a sand bar out beyond the limit of the normal zone of destruction.

Eighth, extremely rapid subsidence may rarely bring deposits into the protected zone with sufficient rapidity for protection.

Note that in most of these cases the deposit formed is not a lens but a node which is in connection with the usual sand sheet above. Since these thickenings are so frequently at the lower side of the sand sheet, they may merely contain water beneath oil, but as shown in the paper by Gardescu and Johnson, differential settling may pull down other parts of the sheet relatively so that the sand may be higher at the nodes formed in this way. A consideration of the methods listed above leads us to expect not only some linearity of these thicker deposits but also occasionally some hook like curves and forked lines.

Pass now to the placing of the overburden upon the source bed and its contiguous reservoir. As a result of this over-

burden, the contents of the voids become in part expressed from the mud. The movement is along the lines of least resistance. Given any one unusually large pore, surrounded by finer ones, any gas bubble would tend to be confined in such space. As this space becomes still smaller this bubble would gradually become pear shaped and a portion of it would be budded off and escape in the direction of least resistance. In general, the movement is along the lines of chains of larger pores and the liquids flow more readily until there is enough gas so that there is a continuous gas space pore to pore. In that event gas will move the more readily. Of the two liquids, oil and water, since the walls are water wetted, adhesion will retain water more than oil. So long as the oil is in such amounts as to exist merely as bubbles the expelled liquid will be mainly water, but with enough oil formed to cause a coalescence of bubbles or a growth of bubbles till an oil passage is established, then the oil will also flow. If there is high viscousity the flow will not be so free, but in any event water will also be expelled.

Summing up, then, the oil entered the reservoir because it was expelled into it since the reservoir is less compactible than the mud. It has difficulty in leaving because the water-wetted walls make movement difficult in fine passages.

The role of capillarity in this segregation of oil and gas in the larger reservoir, we believe has been given too large a part because it has been assumed that the surface tension between oil and water should be measured by the difference between the surface tension of water to gas and that of oil to gas, which is not true. The surface tension of a gas-liquid surface is always relatively higher than a water-liquid surface tension. The water-oil surface has a surface tension of only 27.8 as compared with air-water tension of 81. With this tension the factor of which liquid has first wetted the wall is of paramount importance. So, also, in the surface tension of solids and liquids, one cannot use the constants derived from the study of liquid gas surfaces. In fact, unless specifically referring to other types of surface tension the older authors used the term capillarity is if limited to the gas-liquid phenomena. Until the surface tension of the oil-water surface

is more thoroughly known and more thoroughly studied, much greater caution must be shown by petroleum geologists in appealing to it as an aid in accumulation. Indeed, it is clear that many references to oil-water surface tension suppose it is much the same thing as the gas-liquid surface tension of the text books.

If one confines oneself to a consideration of the gas-oil surface, in competition with the gas-water surface as the cause of capillary segregation of oil and water, then a new difficulty arises, for oil spreads on the surface of a bubble so that one is dealing only with a gas-oil surface. It is well known that a mere film of oil on water in a capillary tube gives the constant for oil rather than for water.

Eventually the contracting of the beds will cease. This time is determined partly by the pressure, partly by the extent to which the gases and fluids in the voids have been expelled, and lastly and probably most important the extent to which the grains are cemented.

From now on the migration of the contents of the voids is increasingly difficult, yet we may be quite sure a great deal still goes on because the alteration of the coals, much of which takes place after cementation, shows conclusively that gas is being formed in important quantities and also that additional light oil is being formed which must find its way into the reservoirs since pressures at any one depth are so equalized.

Pass now to the consideration of the reservoir filled with water into which issues a stream of oil, gas and water, let us suppose in equal amounts. It enters by the lines of larger pores. If the oil and gas exist as bubbles they will have great difficulty in entering fine pores because of the water wetted walls, and hence will remain in the larger pores. Assume, however, there is enough to constitute a stream rather than bubbles. Here also the passage will be along the line of least resistance, avoiding the finer spaces. Note that this is nevertheless the case even though there is no gas present at all and hence no capillarity in the usual sense. The situation may be illustrated by comparing it to the French and Indians invading Pennsylvania. The French move along the valleys and trails with their goods, although the Indians readily enter

the woods, and prefer to advance under their cover. So here the invading water is little restricted, but the invading oil and gas occupy the large pores in their wanderings, due to the fact that water was there first and the walls of the pores are water wet.

Suppose on the contrary, an oil wetted sand invaded by water. The roles are then reversed. The water then as the invader follows the lines of the larger pores.

All the water is not left in the shale, and all the oil and gas expelled, but rather the shale still has oil, gas, and water in it, as does the sandstone. The excess material in the voids of the shale was pushed into the reservoir because it had to go somewhere, and it followed the course of least resistance. Since the three are immiscible, differ in specific gravity, and are moving, gravitational separation can take place. Invasion, not capillarity, is the main agency in forcing the oil into the reservoir. The force producing the invasion is first compacting, second the displacing effect of cementation, and third the expansion caused by the formation of the hydrocarbons.

In this we have an explanation of the two types of pools, encroaching and non-encroaching. In encroaching pools water is the main constituent of the pores of the surrounding zone of lower or finer porosity, in non-encroaching it is filled with oil or gas. If oil is the main filling of the outer zone voids, the decline of the oil is slower; if gas is the main filling of the shale voids it long continues the supply of gas.

Also an explanation is found for the two types of gas depletion. In one for every loss of a pound pressure, there is roughly a similar amount of gas yielded. In this case the shale and transition rock is not gas-filled, but water or oil-filled, and these encroach, eventually drowning the well. In the second case the later pounds lost give many times the amount yielded by the earlier pounds. This finds its explanation in the gas of the outer zone, which slowly contributes gas after the pressure differential has become great.

THE EFFECT OF STRATIGRAPHIC VARIATION ON FOLDING

BY I. I. GARDESCU* AND ROSWELL H. JOHNSON**

When a cloth that has just been woven is wrinkled for the first time, as in the bending of the arm at the elbow, it falls into a series of folds. These folds are determined in part by the rigidity of the cloth, which determines the distance from fold to fold. The exact position of the axis of a fold would be determined if the cloth at any one point had been rendered more resistant to flexure. So when strata are to be folded by lateral compression, the location of the axis, a matter of paramount importance to the petroleum geologist, may be caused in some degree by stratigraphic variation. The petroleum geologist is also very greatly interested in this stratigraphic variation in so far as it may reveal the location of sand bodies. If then these sand bodies have any relation to the folding, it is very well worth our concern. With that in view, experiments have been made with papers the rigidity of which has been altered by simple devices and folded, with the results indicated in Figure 1. This postulates, of course, a sufficient contrast in the resistance to pressure on the parts involved. Just what the minimum degree of contrast is necessary to accomplish these results, we are unable to state at this time.

We are now engaged in the construction of apparatus which may throw light on this point. Meanwhile, we are able to state, that given a more resistant area such as might be the result of a well-cemented sandstone, lying embedded within shales, this area will resist folding to some degree. When folding takes place, such an area will tend not to be on either an anticlinal or a synclinal axis but on a flank of a fold and this flank will be less curved and more straight than would otherwise be the case. There will also be a concentration of stress at the ends of the area so that any possible tendency

*Pittsburgh, Pa.
**Professor of oil and gas production, University of Pittsburgh, and member of firm of Johnson, Huntley & Somers, Pittsburgh, Pa.

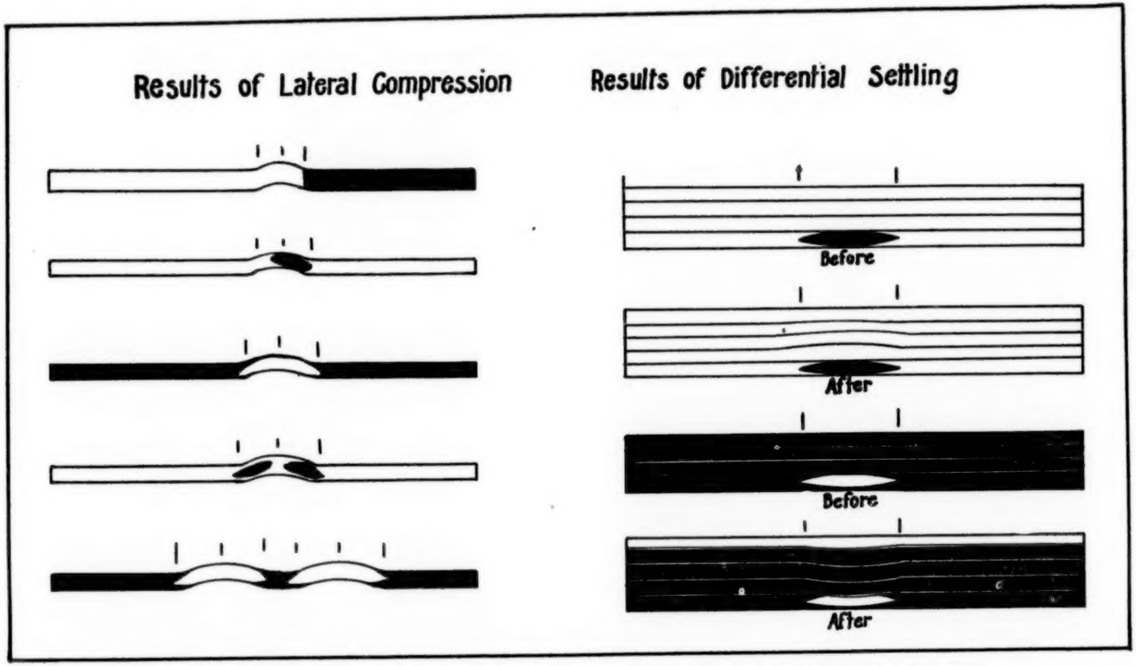

Plate 1. Diagram showing results of lateral compression and differential settling.

to fault would be favored at these points. In the diagrams, the location of probable faulting is indicated by the wedges of two orders of magnitude.

If now, we take the opposite condition of a lens of shale within a body of more resistent sandstone, the opposite will take place. This area will be the locus of folding and we may expect it to be normally up-folding rather than down-folding.

Assume now the case of a very extensive sandstone sheet which eventually tails out or varies into a shale. Under these circumstances, stresses which might result in folding in this more resistant part would be less likely to take place, but folding in the less resistant part would be more likely to occur at the point of accumulation of such stress, so that we would have a fold adjacent to the end of the body in question. If there are two areas of greater resistance, the result will be a fold between the areas with much steeper and less curved sides with the axis of the fold so accentuated as to promote the probability of a fault. On the contrary, with two less resistant bodies which are not too far distant, we will have two upfolds and one down fold between.

In contrast to this type of deformation, the result of lateral compression, if we consider the deformation to be the result of a differential settling, then we will find that the more rigid and hence less compactible body will occupy a position on the crest of the dome, or anticline and the less resistant bodies will find a position on the axis of the syncline or basin.

Note, then, the contrast between the two types of deformation. In the case of differential settling, locations on domes and anticlines are more likely to find the sand body whereas in lateral compression the flanks are favored as against the crest.

There are so many other factors involved in the disposition of folds in the lateral compression type that the factor here put forward could be easily overstressed. It is not possible at this time to weigh its relative importance, the purpose of this communication being to place on record this factor which seems not to have been considered.

THE APPLICATION OF DEPLETION ALLOWANCES TO OIL PROPERTY TAXATION

By Samuel J. Caudill*

INTRODUCTION

As a general rule oil wells reach their maximum output shortly after completion, when all the positive natural factors controlling productivity are more efficient than at any other time. Positive factors are those that assist in the expulsion of oil, such as compressed gas associated with the oil and dissolved in it, and occasionally water and gas pressure in the same stratum. The natural factors tending to retard the output are called negative factors and include frictional resistance in the producing stratum, viscosity and gravity of the oil, and back pressure exerted by the atmosphere. Many others could be mentioned but these are most important.

During the period of maximum production of a well the positive natural factors are exerting their greatest influence, and the decline in production is usually coincident with the decline of these forces. As the effect of the main expulsive forces grow less, the efficiency of the more important negative factors increase, an effect that is manifested by increased frictional resistance in the producing horizon by the accumulation of paraffin, and an increase in the gravity and viscosity of the oil. The life of a well varies with the time that the expulsive or positive factors can successfully combat the retarding or negative ones. When the expulsive energy fails to overcome the retarding forces an early abandonment is necessary, unless artificial means are applied. All wells do not respond to artificial treatment, such as water flooding, use of compressed air or gas, vacuum pumping, steaming, etc., but in many cases satisfactory results are obtained by using one or more of the above methods, resulting in an extension of life and an increase in ultimate yield.

The production of oil entails depletion of the recoverable

*Samuel J. Caudill, Consulting Geologist and Petroleum Engineer, Tulsa, Oklahoma.

underground reserves and as long as a property is commercially productive, depletion allowances should be made. The natural deposits of oil are exhaustible assets and each unit removed reduces the amount ultimately recoverable which in turn reduces the value of the property. To determine the reduction in value through depletion for a given period, it is necessary to know the number of units of oil produced during the period under review and the total recoverable barrels in the property at the beginning of the period. These factors being known, the unit value of the recoverable oil may be obtained. The unit value multiplied by the number of barrels produced will give the amount by which the original cost or value has been reduced. This is considered the fairest and most equitable way of amortizing an investment in an oil property.

During the latter part of 1918 the Internal Revenue Bureau of the Treasury Department collected production data from all the fields of the United States for the purpose of making a study of depletion. Records of individual properties were collected and tabulated, resulting in the construction of generalized decline and appraisal curves for the various fields. The curves demonstrated that it was possible to estimate the recoverable oil from a property with a fair degree of accuracy. Subsequent work by petroleum engineers, however, has demonstrated that such curves are useful only for the purpose of instruction and cannot be applied indiscriminately to specific properties. Most of the curves are based on a number of sands that vary widely in productivity and extent of life.

The production curve method is conceded to afford the best means of estimating recoverable oil. The work, however, must be done with great care and judgment if satisfactory results are to be obtained. It is not difficult to plot the decline of a well and compute its ultimate production when all the data are complete. Unfortunately, however, production records covering long intervals are seldom available and only a short segment of the curve can be constructed. It is necessary, therefore, to project the curve beyond the period of actual production, to ascertain the expectancy and probable life of the property. After the expectancy of the producing wells has been

determined, many other factors have to be considered in computing the recoverable oil from the undrilled area. This work requires a knowledge of the structural geology and the relation of production thereto, the initial pressure of the reservoir, the location of the top of the basal water and the rapidity with which the oil and gas is being exhausted by the completion of other wells in the same pool. Such data cannot always be acquired on the area under investigation and it is necessary to make comparisons with other pools, where the conditions are most similar.

REVALUATION ON ACCOUNT OF DISCOVERY

Where discovery wells have been drilled by the tax-payer he is entitled to deplete the recoverable oil on the appraised value of the property in lieu of the cost thereof. The appraisal has to be made as of thirty days subsequent to discovery. To make a trustworthy valuation under such circumstances one must be familiar with the producing sand and know its life and behavior in other fields. It is essential to know the geological conditions that control the accumulation and retention of the oil and gas, the amount of water usually present, its influence on the cost of operation and development and whether or not production can be expected far down the slope of the structure. Bartlesville sand is more prolific down the west and southwest flanks of anticlines and domes than near their crest. In fact, the productive area will often cross a small syncline or saddle connecting different folds. On the other hand, Wilcox and Dutcher sands are more productive on the crests and higher parts of structural uplifts. Structures, as mapped on these sands, are usually of the accentuated type and unlike Bartlesville sand flexures are more productive on their east flanks.

One of the most important factors in evaluating an oil property is the accurate determination of the recoverable oil. A non-productive property has no value, and other things being equal, a tract that will produce 100,000 barrels is worth more than one that will yield only 90,000 barrels. Hence, the value increases as the recoverable oil increases.

The geologist must ignore psychological factors and inflated values created by undue excitement. Such values usually

exist in the minds of persons inexperienced in the oil business, some of whom have been so successful in other lines of activity that they feel it is a simple matter to become successful oil producers. One venture is generally sufficient to prove that the production of oil requires years of training, experience, and an unlimited amount of capital.

The success of the petroleum engineer depends upon his ability to estimate correctly the productive value of a property. If he recommends the purchase of a lease at a price that proves to be excessive, then the operator has too great an investment in each barrel of recoverable oil, and the property cannot be operated at a profit. In the appraising of properties for taxation purposes, the taxpayer desires the highest value possible, whereas the Government seeks a reasonable valuation. Under the income tax law the value is only material for the purpose of certain deductions, many of which are tax-free, and as they represent a certain percentage of the value, it is evident that the higher the value the greater the deductions, and the lower the taxable income. Under an ad valorem tax, the tax is a percentage of the value and, therefore, the higher the value the higher the tax. This is just the reverse of conditions, as set forth in the income tax law. The petroleum engineer should place a value that will be fair to both the government and the taxpayer. If his work has been properly done, he will not suffer embarrassment if the present law should be changed and the tax figured on an ad valorem basis.

The appraiser should not place an inflated or fictitious value on a property, even though it might be based on the sale of a similar tract in close proximity. If the value established by sale of the other property should be applied to the one upon which a value is desired, and the result gives a high unit cost and an excessive depletion allowance, then such a value should not be used. If the completion of a discovery well should demonstrate a value in excess of that created by sales, then the property should be appraised by scientific methods and the proper value placed thereon.

APPLICATION OF DEPLETION ALLOWANCES

The amount of depletion to be written off against opera-

tions should be handled through the "Lease Operating" statement, rather that the general "Profit-and-Loss" statement, inasmuch as the principle to be followed makes it necessary to determine the depletion allowance for each lease separately. The amounts so determined are credited to "Reserves" which function as "Valuation" accounts to the assets, reflecting the leasehold values.

If the taxpayer claims enhanced valuation, due to ownership of oil properties prior to March 1, 1913, or on account of discoveries of oil or gas on leases hitherto unproductive, after that date, the regulations provide that such appreciated values must be reflected in the books of the taxpayer. The exact method to be employed in effecting a compliance with this regulation is a moot question. A simple method that is frequently used is here outlined: the appreciated value may be charged to a distinct asset acount appropriately named and the credit carried in an account under "Special surplus appreciation."

In the calculation of depletion of properties having an appreciated value, it is necessary to determine the amount of depletion applicable to cost and the amount applicable to appreciated value. The amount based on cost is clearly a direct deduction from operations. The amount based on appreciation, although allowed as a deduction by the government in computing net income, should receive a different treatment. One method, that seems to be founded on correct accounting procedure, is to charge the so-called depletion of appreciated value to the "Special surplus" account which was credited to reflect the liability offsetting the increase in assets through appreciation. This treatment operates as a transfer to the "Earned surplus" account of the depletion of apreciated values, which is referred to as the "Realization of appreciation through depletion." The fact that this amount is allowed as "Invested capital" by the Treasury Department seems to warrant its transfer to "Earned surplus."

In order to more clearly reflect the method above outlined, certain facts and figures will be assumed and the computations made:

(a)	Cost of leasehold	$ 1,000.00
(b)	Discovery value claimed by taxpayer and allowed by Commissioner	10,000.00
(c)	Depletion allowed for period	4,000.00
	Deducting the cost from the discovery value, the appreciation is	9,000.00

Applying the ratios indicated above, the total depletion sustained is divided into the following components:

(d)	Applicable to cost	400.00
(e)	Applicable to appreciation	3,600.00
		$4,000.00

In the determination of net income, the taxpayer is entitled to a deduction of $4,000.00 on account of depletion sustained. This amount will be shown as a deduction from profits and carried as a reserve for depletion. Of this amount $3,600.00, however, represents an excess which has no relation to actual investment in the business.

Suppose a corporation has, at the beginning of the year, a surplus of $150,000.00 and net income for the year before deducting depletion of $50,000.00. Let us trace the changes brought about through computations reflecting depletion:

NET INCOME

Income before depletion	$ 50,000.00
DEDUCT: Depletion	4,000.00
TAXABLE INCOME	$ 46,000.00

EARNED SURPLUS

Balance at beginning of year	$150,000.00
Net income	46,000.00
	$196,000.00
Realization of appreciation through depletion	3,600.00
SURPLUS, END OF YEAR	$199,600.00

SPECIAL SURPLUS-APPRECIATION

Credit through discovery revaluation	$ 9,000.00
DEDUCT: Realization of appreciation through depletion	3,600.00
BALANCE TO BE RETURNED	$ 5,400.00

In addition to the above, the assets will reflect an additional charge of $9,000.00, representing the appreciated leasehold value, and the "Reserve for depletion" will carry a credit balance of $4,000.00.

PRESENT STATUS OF OIL AND GAS PROSPECTS IN MISSISSIPPI

BY E. N. LOWE*

HISTORY OF DEVELOPMENTS

Oil developments in Mississippi commenced in 1910 when a well was drilled by local capital in Lauderdale County not far from the Alabama line. This well began in the Wilcox formation and reached a depth of 2,850 feet. No log is available. The next year a local organization under the advice of an "oil smeller," drilled a well near Pascagoula, on the Gulf Coast to a depth of 3,010 feet. At a depth of 2,250 feet in the Vicksburg formation, according to Matson, warm salt water with some gas was encountered.

No further interest was manifested in Mississippi as a possible oil territory until 1918 when U. S. Geological Survey Bulletin 641D appeared. The work for this bulletin was done by O. B. Hopkins at the advice of E. W. Shaw. As the outcome of Hopkins' recommendations the Mississippi Oil, Gas & Investment Company, a local organization, drilled two wells near Vicksburg, on the Vicksburg monocline, the first being 3,462 feet and the second 2,630 feet deep. Two other wells were drilled near Jackson on the Jackson anticline, one by the Arkansas Natural Gas Company, depth 3,043 feet, the other by the Atlas Oil Company, depth 3,079. The first of these wells is reported to have had a show of oil in the Selma chalk at 2,640 feet and to have stopped in this formation. The Atlas Oil Company also drilled two wells in Jackson County, near the Gulf Coast.

The third and present oil excitement commenced in 1920. Reports of "gushers" are frequently published and a few wells have actually had "shows" of oil.

GEOLOGY

Mississippi lies wholly within the Gulf Coastal Plain. In a very small area, of two counties, lying in the northeast cor-

*State Geologist of Mississippi.

ner of the state, near the Tennessee River and the headwaters of the Tombigbee, the Paleozoic formations are exposed in the channels and lower slopes of streams. Even in this small area the dividing ridges are capped with Cretaceous gravels, sands, and clays. Exclusive of these old rocks, which form the floor of the original embayment, the geological formations of the state range from recent river alluvium and coastal deposits, through the Pleistocene and all the Tertiary divisions, to, and including the Upper Cretaceous.

Throughout this column of approximately 7,500 feet, alternations of sands, shales, limestones, and lignites occur. Limestone occurs at four notable horizons, two in the Tertiary, and two in the Cretaceous. Except in the lowest limestone in the column, the Selma chalk of the Cretaceous, these limestone horizons exhibit no single thick bed, but consist of thin beds interstratified with marls and limey shales. The Selma chalk, however, presents usually a solid mass several hundred feet in thickness. Sands and shales are the prevailing feature of the geological column in Mississippi, with lignite, either in beds or impregnating the shales. Contradictory to expectations, shale and lignite appear to be more abundant in all these formations toward the axis of the old embayment than farther east. They are more abundant in western than in eastern Mississippi, and also more abundant in eastern Mississippi than in Alabama. It is a noticeable fact that the Selma chalk becomes less chalky and more aluminous in Mississippi than in western Alabama, and as it approaches nearer the axis of the embayment in Tennessee it becomes a calcareous shale. Wells recently drilled in western Mississippi indicate the same change there in the Selma.

These facts have some bearing upon the possible occurrence of petroleum in commercial quantities in the state. The shales rich in organic matter seem to furnish a possible source of hydrocarbons, and the numerous sand horizons furnish under favorable structural conditions adequate reservoirs for accumulation. Given these facts, two questions are raised: Are the structural conditions present that favor accumulation of petroleum? Have the metamorphic changes affected these strata sufficiently to produce oil or gas?

While in Mississippi a number of low structures have been discovered none has been found at all comparable to many uplifts that so markedly affect the Cretaceous in Louisiana, and no faults of any consequence are known to exist within this territory. The second question must go as yet unanswered. The absence of marked disturbance, either by folding or by faulting, by which metamorphism is produced, may furnish a key to the answer.

The Upper Cretaceous in Mississippi is represented by four divisions. The Ripley, the uppermost division, corresponds approximately with the Nacatoch of Louisiana, and is largely a sand formation; the Selma is an aluminous chalk limestone; the Eutaw is a dark greenish marine sand; the Tuscaloosa, which approximately represents the Woodbine in the western part of the embayment, consists of shales, gravels, and sands. The uppermost shales are dark in color, but pass down into reddish-brown, coarse sands, which in turn pass downward into a deep Indian red shale. There is 100 feet or more of each. At the outcrop near the Alabama line these red shales, overlain by thick gravel deposits, form the very base of the Tuscaloosa, lying upon the Mississippian sandstones and limestones.

At Winona, Montgomery County, in north central Mississippi, aproximately 100 miles southwest of the outcrop of the Tuscaloosa, this red shale horizon is struck in a well at a depth of 3,100 feet, and for 225 feet the drill shows alternate red shale and brown sand cuttings. Below this to the depth of 3,500 feet, white sand with salt water prevails. The brown sands are coarse and round-grained, and give a slight chloroform test for oil, but there was no oil show in the well.

In view of the fact that the bit in this well is now more than 500 feet below the top of the red shale which is supposed to be the base of the Tuscaloosa at the outcrop, the question has presented itself, "Is the 500 feet of material below that horizon Tuscaloosa, or does it represent Lower Cretaceous?"

At the present depth of 3,600 feet red shale is again encountered in the well. A comparison of this well with the Bollinger No. 1, of the Empire Gas and Fuel Company, in Choctaw County, Alabama, strongly suggests the probability

of Lower Cretaceous at the bottom of the well. No oil has been encountered.

FAVORABLE HORIZONS

Mississippi Geological Survey Bulletin No. 15, on "Oil and gas prospecting in Mississippi," noted twenty wells that had been drilled for oil and gas in this state up to that date. Of that number five had reached to a depth of 3,000 feet or more. Three of the five had penetrated into the Cretaceous, two of them stopping in the Selma chalk, and the third one, at Vicksburg, stopping in the Eutaw at a depth of 3,462 feet. None reached the Tuscaloosa.

At this writing ten wells are being drilled in the state for petroleum. Of these, two have reached a depth in excess of 3,500 feet, one after reaching a depth of 3,200 feet has been abandoned, and one, somewhat in excess of 3,000 feet, has also been abandoned. One of the 3,500 foot wells is located near the Gulf Coast. Fossils taken from the bottom of the hole and submitted to the United States Geological Survey for identification proved the horizon to be either Jackson or Claiborne. The other 3,500 foot well, as already stated, is located near Winona, Montgomery County, in north central Mississippi in the lower Claiborne outcrop, and has reached the Tuscaloosa sands, and probably the Lower Cretaceous—the only well in Mississippi that has reached that horizon.

Most of these wells are not drilled on structure, and where they are, except in a very few instances, the structures are low and the foldng possibly does not reach down to the Cretaceous horizons. The uniform failure to find oil, even in small quantity, to say the least, is not encouraging. Still these drillings, if they prove anything, establish the fact that the Tertiary sands of Mississippi are not petroliferous. Should more favorable structures eventually be found, however, even this fact may be disproved.

They probably prove nothing about Cretaceous possibilities —certainly not about the possibilities of the Tuscaloosa. The Ripley, correlated approximately with the Nacatoch sand of the Louisiana section, has been reached in a few of these wells, and in northeast Mississippi, where it is not so deeply buried,

it is a favorite water sand. It seems improbable that the Ripley horizon will prove petroliferous anywhere in Mississippi, unless possibly in the extreme western part beneath the northern delta, where structures have so far not been detected. The Selma is too dense to serve as an oil reservoir. The Eutaw is a medium-coarse, round-grained, marine sand, and would make an ideal oil reservoir, but in the few deep wells that have reached it, this sand horizon has proved disappointing, yielding only fresh water.

In much of the northeastern prairie section of Mississippi and the sand hills region about the headwaters of the Tombigbee, wells get an abundance of fresh water of excellent quality from this horizon. Heretofore this water has been, in part at least, referred by geologists to the sands of the Tuscaloosa, but within this year (1921), as a result of recent drillings, views as to the horizon of these water sands have changed. It is extremely doubtful if the Tuscaloosa is reached in these water wells; their water is from the Eutaw. Under strong folding the Eutaw appears to be a promising reservoir for petroleum where capped by several hundred feet of impervious Selma chalk, and underlain by carbonaceous shales of the Tuscaloosa 100 feet or more thick. The Eutaw needs further prospecting.

During 1920 considerable interest centered in a reported oil find in a well at Okolona, Chickasaw County. The well was a water well, but the water had such a strong odor of petroleum that the pump was drawn and 100 or more gallons of dark brown oil was obtained from the top of the water. The well is less than 600 feet deep, and stops in the upper part of what is presumably the Tuscaloosa. Suspecting the probability of the well being salted, several different tests of the oil were made. In one instance several gallons were sent for a refining test. None of these tests gave satisfactory results, so that the question as to whether the well was salted or not remains unsettled. Undoubted oil shows occur, however, in a number of wells throughout the region, and these shows raise the hope that an oil sand lies below, either in the Cretaceous, or possibly in the Paleozoic rocks from which petroleum escapes through a fissure or fault.

So far as is now known, there are no determinable folds beneath the Cretaceous prairies. Possibly more detailed work will reveal small folds. Whatever structures of major importance may hereafter be found will probably be superimposed upon folds of the Paleozoic beds, and will merely reflect the structure in these formations. These old formations which lie beneath the Cretaceous in Mississippi are the Mississippian and Pennsylvanian. The Pennsylvanian beds are not positively known to occur in this state, but they almost certainly underlie the Cretaceous beneath much of the state. Near the Alabama line in Tishomingo County the Mississippian rocks, sandstones, limestones, and shales, outcrop in the stream valleys immediately beneath the Tuscaloosa red shales, and are distinctly petroliferous; they are probably so beneath the Cretaceous of Mississippi.

Where the Paleozoic rocks enter the state they form the southern extension of the Cincinnati Anticline. There can be no doubt that the rocks are distinctly folded and that these folds pass beneath the Cretaceous. The general direction of the major fold is toward the southwest, minor folds paralleling and radiating from the main uplift.

In this region of the state where the Cretaceous rests upon folded Paleozoics, will be found the most promising field for oil development in Mississippi. The basal sands of the Tuscaloosa, or of the Lower Cretaceous, if present, lying immediately above the contact, would receive petroleum from the oil-bearing Paleozoics below by fissuring or faulting of the older rocks, and under favorable structural conditions would form accumulations.

The Paleozoic horizons under similar conditions would offer favorable opportunities for production. In northeast Mississippi these could be easily reached, but more than one hundred miles west or south of the outcrop the depth is almost prohibitive. Furthermore, it would be extremely difficult to determine if the folding continued so far.

CONCLUSIONS

Coastal salt domes have not yet been found in Mississippi, and until they are discovered, the chances for successful oil prospecting in south Mississippi are not good.

The Tertiary formations have been penetrated repeatedly in different parts of the state without finding oil or gas, except a show of gas at Jackson in the basal Claiborne or Wilcox. Tests have in only a very few instances been upon structure, but the uniform absence of oil shows (authoritatively determined to be such) suggests the absence of petroleum in these formations.

The Ripley of the Cretaceous has been frequently tapped without as yet revealing oil shows. The Selma, where penetrated by numerous wells, has failed to yield petroleum even in small quantity. The Eutaw looks promising, but has yielded only fresh water.

The Tuscaloosa, and whatever formations lie below it, are as yet untested, but with all the evidence before us they offer the best chance of finding oil in Mississippi. No well has as yet entered the Paleozoics of Mississippi, or has even reached the Cretaceous-Paleozoic contact. One well near Columbus, Lowndes County, now a few hundred feet down, promises to be one of the most important tests undertaken in the state, because of its position upon the south slope of the old Cincinnati uplift, with less than a thousand feet of Cretaceous intervening. This makes it possible to enter the old rocks to a depth of 2,000 feet if necessary. As these rocks are known to be petroliferous, the chance of securing production seems unusually good.

DISCUSSION

ON "GRAPHIC METHOD FOR DETERMINING THE SURFACE PROJECTION OF THE AXIS AND CREST TRACES AT ANY DEPTH OF AN ASYMMETRICAL ANTICLINE" BY D. M. COLLINGWOOD

On page 159 of the Bulletin of the American Association of Petroleum Geologists, Vol. 5, No. 2, there appears an article by D. M. Collingwood,

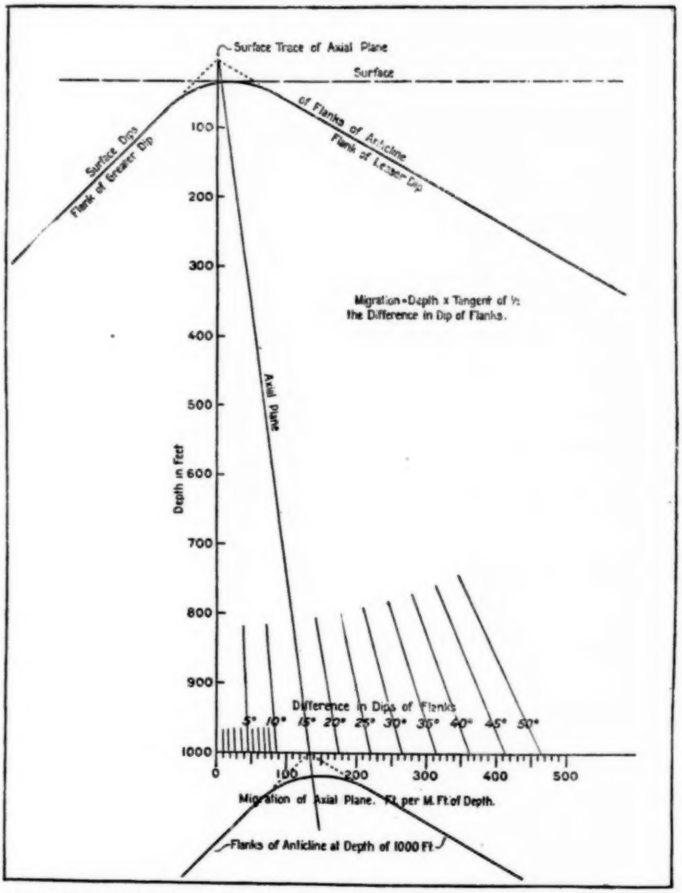

Fig. I, Chart showing migration of axial plane of asymmetrical anticline.

in which there appears to be an error. The diagram on page 160, would indicate that an asymmetrical anticline whose flanks dip 8° and 2° would offset 5.7′ for every 10′ of depth. Whereas, the offset would actually amount to only 5.2′ for every 100′ of depth. Obviously the decimal points were either omitted before the figures of the middle scale, or else ciphers were omitted after the figures representing degrees on the right and left hand scales, making said scales read from 0° to 9° instead of 0° to 90° as was probably intended.

Presented herewith is a chart (Fig. 1), which I prepared two years ago for the solution of this problem, and which has proven useful in California, where asymmetrical anticlines are found whose flanks dip as much as 65° on the steep side and as little as 10° on the side of lesser dips. This diagram has, I think, the advantage of being a better grapic picture of the problem, and of being read without the use of a straight edge. The chart is self explanatory, and I only need mention that it is the difference in the dip of the flanks, and not in the amount of the dips which governs the migration or displacement towards the side of lesser dip.

Thus, the axial plane of the asymmetrical anticline whose flanks dip 30° on one side and 45° on the other side, will be identical with the axial plane of the asymmetrical anticline whose flanks dip 10° on the side of lesser dip and 25° on the side of greater dip, and this may readily be demonstrated on the accompanying diagram.

HUGH B. WEBSTER.

ON "THE TIME FACTOR IN THE ACCUMULATION OF OIL AND GAS," BY R. H. JOHNSON

The conditions under which organic mater accumulates appear to the speaker more important than the character of the organic matter. Wherever at the bottom of a body of water circulation for some reason is poor, oxygen in the water becomes exhausted, hydrogen sulphide forms and conditions are favorable for the accumulation of organic matter (plant mater foraminifera, fish and other swimming and floating organisms) that settle from above. Such conditions exist for instance in deep holes in Chesapeake Bay and its tributaries where black muds accumulate, and similar occurrences have been described off the mouths of rivers on the Atlantic coast of the United States, in the familiar case of the Black Sea, etc.

M. I. GOLDMAN.

EDITORIAL

THE NUMBER OF AMERICAN GEOLOGISTS

On July 5th a list of the members of this Association was distributed. An analysis of the addresses has been made and is here given. It shows that an effort must be made to interest geologists outside of the Mid-Continent field in the Association and this can be done by publishing in the Bulletin papers of general interest dealing with other fields. This is possible only by cooperation of the members submitting such material to the Editor.

	Active	Associate	Total
New York City	34	1	35
East of Mississippi (Except New York City)	89	21	110
Mid-Continent and Louisiana	316	92	408
Gulf Coast	41	5	46
Rocky Mountain	44	4	48
California	26	1	27
Foreign	45	2	47
Total	595	126	721

In connection with this analysis of memberships, an analysis of "Geology and geopraphy in the United States" by E. B. Mathews and H. P. Little recently published by the National Research Council is reviewed. Their study of information regarding nearly 2,500 men who have received instruction or shown interest in the combined subjects of geology and geography in America showed that 1,275 of these men are "interested in geology and geography and more or less active in the development of these sciences." It is obvious that a large part of the membership of this Association is not included among the 1,275 because the membership includes many young men who are primarily interested in commercial work or business and who have little interest in the science of geology.

Analyzing the training of the men selected, no collegiate record is available of 10%, only 3% are non-collegiate, 15% have only a Bachelor's degree, 22% only a Master's degree, 32% a Doctor's degree, and 18% were graduate students who did not receive a higher degree. The majority of those without collegiate degree are in oil work.

The average annual number of college graduates during the past ten years who have entered geology have obtained degrees as follows: Bachelor 40, Master 20, Doctor 18. For every hundred men now in geology who have received collegiate training, 50 took a Master's, 39 a Doctor's degree.

The scarcity of geologists among college graduates is significant. For the years 1895-1914 inclusive the total number of degrees awarded in the United States and those who have become geologists are listed:

	All Degrees	Geologists	Percent
Bachelor	292,000	658	0.22
Master	36,950	313	0.70
Doctor	7,160	237	3.3

Further emphasis of the scarcity of geologists with collegiate training—and 87% have such training—is shown by the previous figures that an average of only 78 did enter the science annually. Many more men now annually enter the profession of petroleum geology, but their work has added little to the published record. Contrast the figures with those given by Mr. E. G. Woodruff elsewhere in this Number, prophesying the number of positions which will be available for geologists, as such, in petroleum work in the future.

Geology is taught in about one half of the 571 institutions of higher learning in this country and 101 of them have graduate students in geology.

Publications by geologists now average about 1,100 annually, 45% of them being less than five pages in length, and 47% being devoted to "applied geology." About 1,100 authors during the past decade are included among the 1,275 geologists analysed—a remarkably high average. The anual production of papers on North American geology would occupy ten to twelve shelf feet.

The public finances geological work, for 60% of the published matter is based on work done with public funds. The gross amount of expenditures in geology annually by Federal and State governments exceeds $3,000,000.00. Oil companies must have spent twice this amount annually during the past few years.

In other words, at the rate of public expenditure, an average of only $4,000.0 for salary, expenses, and overhead would be expended on each geologist anually. This calculation, although obviously too low, indicates the fact that the average geologist not in commercial work is greatly underpaid. A few in petroleum work are well paid and the glamour of the recent oil frenzy added to this fact has led the undergraduates of a number of state universities to believe that petroleum geology and fabulous wealth go hand in hand.

S. P.

PUBLICATION RULES

The following rules of publication have been drawn up for the benefit of the Association members and are subject to revision and amendment at the next meeting and to interpretation by the Editor.

(1) Papers presented at the meetings or offered for publication become the property of the Association and shall not be published elsewhere prior to publication in the Bulletin except by consent of the Editor.

(2) Papers published prior to the meetings elsewhere than in the Bulletin can be reproduced in full or in abstract by the Association only with the consent of the Executive Committee.

(3) The Editor is empowered to limit the length of papers offered and to refuse those which for any reason are not suitable for publication.

(4) The cost of proof correction in excess of five per cent on the cost of printing and the cost of necessary revision of copy or reconstruction of illustrations shall be assessed on the author.

(5) The author or authors of each article occupying four pages or more of text shall each receive twenty-five "separates" without charge. Any number of "separates" may be ordered through the Editor in advance of publication at an advance of ten percent on the printer's charge, which is approximately one cent for each page per copy.

(6) The Editor accepts the usage of the U. S. Geological Survey in regard to diction, as set forth in "Suggestions to Authors," by G. McL. Wood, which can be obtained from the Survey free of charge.

SUBSCRIPTION PRICE

This Bulletin is now issued in six Numbers annually, the subscription price for the current Bulletin being $5.00 for the year. Membership dues are $10.00 a year; hence, the Bulletin may be procured more cheaply by subscription than by joining the Association. The Executive Committee will have to consider the subscription price for the next Bulletin before the next annual meeting and therefore every member is urged to communicate his views regarding this matter to the Secretary as soon as possible.

GEOLOGICAL NOTES

THE BURBANK FIELD, OSAGE COUNTY, OKLAHOMA

The initial well of what is generally known as the Burbank field was brought in by the Marland Refining Company May 18, 1920. The productive sand was found at 2,950 feet and the well showed an initial production of 760 barrels per day. Intense interest and activity followed and within twelve months 35 wells had been completed, with an average initial production of around 420 barrels after shooting.

The structure of the field is well known and consists of two domes, the crest of one being in the NW corner of T. 27 N., R. 6 E., and adjacent areas, and that of the other being in sec. 9, T. 26 N., R. 6 E. While geologically these two domes are distinct and separate structures, the production has spread out from each dome until there is every indication that the two producing areas will connect, forming one large field. It is now apparent that, although this pool was opened by a test based on geologic structure, the production has pushed out beyond the limits which would ordinarily be placed on such domes. There is reason to believe that the sand pinches to the east and northeast of the field, which may have considerable bearing on the future limits of production.

Several tests made of the oil from different wells give a gravity of around 38 degrees Be., although different wells showed gravity test ranging from 38 to 35 degrees Be.

The average depth of the sand, subject of course to variations in surface elevations, ranges from 2,755 in sec. 9-26 N-6E to 2,950 in sec. 36-T27N., R5E, with an average thickness of 50 feet where drilled through.

In a new field there is always considerable interest manifested in the decline of production. While it is not feasible to go into detail at the present moment, certain generalizations are perhaps worthy of note. Three wells picked at random in the field showed a decline of 52 per cent in their first month of production. Four wells likewise picked at random, showed an average drop of 53 per cent at the end of their first two months production. At the close of three months production five wells declined 64 per cent. On the other hand, 4 wells showed a decline of only 56 per cent at the end of 5 months production. One well declined 74 per cent in 7 months, while another showed only 59 per cent decline at the close of one year. The above percentages are offered only as facts of general interest and it is realized that each and every well must be studied in itself and in its relation to other wells before being used as a basis for any important conclusions regarding the rate of decline or causes of variation in the same.

There are 4 pipe line companies now in the field, the Prairie, the Oklahoma Pipe Line, the Gulf and the Marland.

At the present time the Burbank pool is the center of interest and we may expect considerable activity in this general region despite the present condition of the oil market.

W. Z. Miller.

NOTES ON SEQUOYAH COUNTY, OKLAHOMA

In Sequoyah County there is an interlacing system of shoestring anticlines of unusual length. Production, mainly gas, has been found there in all tests located on anticlines, as at Vian and Muldrow. An analysis of coal 20 feet below the surface, recently made by Gilmore and Company, of Tulsa, shows a fixed carbon ratio of 93.54 per cent.

Two regional peculiarities in Sequoyah County have not, to the writer's knowledge, been published. First, the base of the Pennsylvanian dips rather steeply to the south from the Tahlequah quadrangle across the region of these folds so that only the drill can tell the thickness of this system at any point. In this connection, it should be added that this is the transition zone between Taff's Winslow of the Muskogee quadrangle and his heavier Atoka-Boggy of the eastern Oklahoma-Arkansas Valley trough so that extreme depths are not predicted for the Vian-Muldrow region.

Second, the steeper side of these folds is on the southeast. This signifies that the latest impact came from the Ouachita rather than from the Ozark uplift. Probably the asymmetrical character of the folds is merely a corrolary of the thickening of formations in this example of geo-mechanics.

Charles T. Kirk.

SOUTH BEND FIELD, YOUNG COUNTY, TEXAS

A year ago Young County, Texas, was described by oil men as adjoining Stephens County on the north. The South Bend field in the south central part is now sufficient reference.

Production from the sands of the Strawn formation dates back many years and is wide-spread over the North Central Texas field but the most important pool so far developed from these sands is at South Bend. Here, commercial wells have been procured from six distinct sands of this formation, which in the discovery wells were found at depths of 1,848, 1,898, 2,106, 2,156, 2,545 and 3,019 feet: in the Roxana Petroleum Corporation Donell and Pratt, Oklahoma Petroleum & Gasoline Company Graham, Ray Colcord Scott, Panhandle Refining Company McCluskey, and Panhandle Refining Company Scott wells respectively. Wells having initial yield as high as 2400 barrels daily have been secured. The first, second and fourth sands have proved to be productive over the most widespread area and the third, fourth and fifth the most prolific.

In this field an average well would penetrate 4,500 feet of Pennsylvanian strata, viz: 300 feet of the Cisco, 950 feet of Canyon, 2,000 feet of the Strawn (including Millsap) and probably as much as 1,250 feet of Bend if drilled down to the Ellenberger lime of Cambro-Ordovician age.

The outcropping strata are more strongly folded in the South Bend district than is common in this part of Texas, several sharp and extended plunging anticlines or "noses," plunging in direction from north-

west to southwest being evident. No less than five pools have been developed on these various folds. The producing area of the main field extends four miles east and west and nearly two miles north and south.

The main pool includes the Graham and McCluskey leases and is located one mile west of the town of South Bend. As mapped on the Bunger limestone of the Cisco formation, it lies between the thirty and seventy foot structure contours, below the highest part of the largest of the northwest plunging anticlines. But the structure of the producing sands instead of being a plunging anticline is a normal anticline with closure of more than thirty feet.

The southeast dip developed in the Strawn sands is not present in the Canyon formation; therefore it is postulated that folding in a northeast-southwest direction occurred during middle and late Strawn time. However, sand lenses or nodes doubtless account for part of this structure. While no paying well has been developed in the Bend formation, the sharp folding present in the overlying formations and the presence of porous strata and traces of oil and gas in the four deep wells which have been drilled, presage success in the more favorable parts of the field.

Development work in this field has been held back first by lack of pipe line facilities and secondly by the declining price of oil. However, the output for the last three months has been at a rate of three million barrels per year. The production decline curve for wells in the South Bend field compares favorably with the average Oklahoma well decline curve.

This field assumes further significance because of its location on a nearly east-west trend of general upfolding along which other sharp local structures exist. Test wells drilled from six miles west to twelve miles east have encountered the various sands of the South Bend field and where well located structurally these tests have secured production of oil and gas. Several other wildcat tests located on these folds are now being drilled.

M. G. Cheney.

THE OIL FIELDS OF MEXICO

Mexico's oil districts have always been a source of interest to the American geologist irrespective of whether he has ever had a direct connection with them. But the majority of geologists have only a vague idea of the location and extent of the various pools; "somewhere near Tampico" locates everything. The geologic literature on the oil regions is scattered; the writer knows of no publication containing a map or description of the location of the various pools to which an interested party may turn for reference. Having received numerous requests for such information it is solely with the idea of supplying that need and making the Bulletin of real service that the accompanying map has been prepared. The map covers what is known as the "Southern" or light oil district from which the bulk of Mexico's production is now being drawn.

The insert shows the location of this district and that of the outside pools of Ebano, Topila, Panuco, and Furbero.

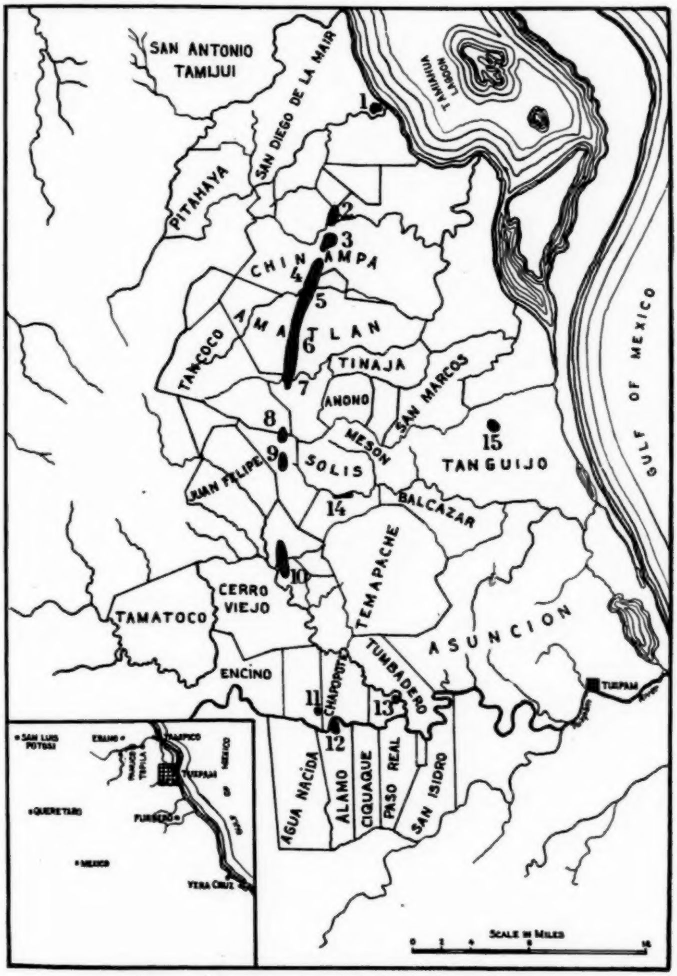

Fig. 1. Map showing the oil fields of Mexico.

Taking up the fields in the order of their discovery, No. 1 is the famous Dos Bocas pool opened in July 1908. The discovery well im-

mediately caught fire and burned till salt water encroachment extinguished it and ruined the field in the fall of the same year.

No. 3 is the Juan Casiano pool opened in September 1910 and now entirely gone to salt water.

No. 10 is the Potrero del Llano-Alazan pool opened several weeks after Juan Casiano and which has suffered a similar fate. Potrero No. 4 in this pool was the major well and produced upwards of 115,000,000 barrels of oil before it failed.

No. 12 is the Alamo pool opened in 1913 and also drowned out by salt water.

No. 5 is the Los Naranjos pool opened in 1913.

No. 2 is the Tepetate pool opened in the fall of 1915. The Tepetate and Casiano pools are undoubtedly one district, the half mile of barren area between them not being due to dry country but merely because no wells were completed in the area before the salt water invasion ruined both pools. The two names are due to the location of wells on different haciendas.

Early in 1916 the Cerro Azul pool (No. 9) was opened. Well No. 4, the major well was rated the largest well in the world at around 200,000 barrels per day. This measurement was made with a flume and although probably inaccurate indicates the gigantic capacity of the well.

From 1918 to 1920 the Naranjos pool was extended north into the Chinampa district (No. 4) the new name due solely to the northern wells being located on an hacienda of that name. This northern development while located on the same general fold cannot be considered part of the Casiano pool because two actual dry holes were completed in the intervening area.

Zacamixtle (No. 7) was opened in the fall of 1920 but the discovery well of the Huasteca Co. was an eastern edge well and quickly went to salt water. The extension of the pool to the south is cut off by dry holes. The pool was immediately extended north into Amatlan (No. 6) till now there is a continuous field proved up to Los Naranjos. Thus it can be seen that Southern Chinampa, Naranjos, Amatlan and Zacamixtle are in reality one continuous and distinct field. Of this area Zacamixtle and Southern Chinampa, being the low ends have gone to salt water with the exception of a few strategically located wells.

Toteco (No. 8) was opened immediately after Zacamixtle by two monster gas wells which soon blew into oil. The pool is merely a northern extension of Cerro Azul, though probably structurally higher, the hacienda name again giving rise to a new field name.

No. 11 is Tierra Blanca, recently opened and which is undoubtedly a distinct field.

It will be noted that all of these pools have a remarkable alignment —this is the famous 'knife edge ridge' of the trade journals. Geologically this is a long undulating anticline in places over 400 feet high. The alternate high and low spots account for the separation of the various

pools. Some faulting probably occurs on the sides of this fold, particularly at Tepetate. The knife edge character of the fold is indicated by the narrowness of the producing area, less than a mile wide throughout its entire extent.

Three pools are indicated off of this major fold. No. 15 is the Tanguijo pool producing from the Tertiary formations and of negligible size and account. No. 14 is the Tierra Amarilla district which produced some oil with a large amount of salt water and which is now of no account. No. 13, the Molino district, represents one well—and rather a freak well. Completed in December 1917 it was rated a gusher of 11° Be. oil at 2,713 feet, the deepest producer (gusher class) in the south fields and the one exception that proves the rule of the salt water level. Just east, across the river, is a deep dry hole and just a few hundred yards southwest is an offset dry hole. An attempt was made to exploit the well but the heavy oil clogged the line and it broke in several places.

There is superficial evidence of a fold parallel to the main fold and just east of it and in line with these two latter fields but tests have failed to prove commercial pools upon it.

A fair amount of outside drilling has been done, both upon seepages and superficial anticlines but so far without results.

Burton Hartley.

OIL AND GAS IN MARION, CHASE, DICKINSON, MORRIS AND GEARY COUNTIES, KANSAS

Marion, Chase, Dickinson, Morris and Geary counties are grouped a little east of the center of Kansas, covering about 3600 square miles.

The resistant limestone beds and alternating shales, form well-defined eastward facing escarpments with long gentle dip slopes to the west. The area is drained by the Republican, Smoky Hill, Cottonwood and Neosho rivers.

Although a number of tests had been made throughout this area, nothing of commercial importance had been found prior to the opening of the Elbing field in northern Butler county. This discovery made in August, 1918, was followed by extensive testing of the country lying to the north, which resulted in the opening of the Peabody, Covert-Sellers, and Florence-Urschel fields in the order named. At the present time the Florence-Urschel field is the only one in southern Marion county in which any drilling is being done on other than inside locations. The extent of the others is apparently well defined. The over-production of oil and the consequent cut in price and pipe line runs, has been the cause of material curtailment of activity in these areas. While drilling outside of these productive areas has been fairly active, there have been no very encouraging results.

½Published by permission of the State Geologist.

The formations found here are as follows.

- Cretaceous
  - Dakota sandstone
- Permian
  - Wellington formation
  - Marion formation
  - Chase formation
  - Council Grove formation
- Pennsylvanian
  - Wabaunsee formation

Recent drilling has proved the existence of a buried ridge of crystalline rocks extending in a north-northeast direction from the southern part of Butler county into the southeast corner of Nebraska, the crest of which appears to cross this area from the southwest corner of Chase county to the northeast corner of Morris county. It is very probable that earth movements due to the presence of this crystalline mass have exerted an important influence on the character of the lower Pennsylvanian sediments and consequently on the accumulation of oil and gas. The wells reporting granite in this area are listed below.

Location	County	Farm	Company	Granite Depth	Granite Penetration	Elev. of well
34-19-7	Chase	Poor Farm		1905	705	1203
2-20-7	Chase	Kaufman	Empire	1890	1165	1388
4-18-7	Chase	Anderson		2110	515	1400
15-18-6	Chase	Whitney		2427	14	1400
5-18-6	Chase	Southwick	National	2515	8	
7-19-6	Chase		Markey, J. H.	2585		
25-20-5	Chase	McLinden	Prairie	3040	10	1331
7-22-4	Marion	Milne	Watchorn	3355*	260	1422
11-16-7	Morris	Hiegle		1900	250	1450
24-15-7	Morris	Whiting	Echo	2512	39	1380
34-17-7	Morris	Moffet	Empire	2506	102	1560

*Metamorphosed schist instead of granite.

The following table lists the rocks exposed in the southern Marion county fields and gives their approximate thickness.

	feet	
Permian system		
Big Blue group		
Marion formation		
Pearl shale	34	2 ft., soft porous lime at top
Herington limestone		
Limestone	5	Buff, massive, fossiliferous.
Shale	7-10	
Limestone	2	
Enterprise shale	32	
Luta limestone		
Limestone	16	White, dolomitic, concretionary at
Shale	5-10	base.
Chase formation		
Winfield limestone	3-10	Quite cherty.
Doyle shale	50-60	
Fort Riley limestone	45	Massive, buff, considerable chert.
Florence flint	20	Quite resistant.
Matfield shale	60-70	

The most noticeable difference between the rocks as revealed by the drill in this area and the corresponding sections published for eastern

Kansas, is the greater proportion of limestone, especially in the Shawnee, Lansing and Kansas City formations. If the well logs have been correctly recorded and interpreted, the first sea during Pennsylvanian times to cover completely the granite ridge in this area was that in which the Nowata or possibly the Bandera shale was deposited. Consequently any of the formations below this horizon may be absent depending on the position of the well with respect to these crystalline rocks. Tests in localities where the granite occurs at greater depths, have found rocks older than Mississippian age which are probably Ordovician.

The northeast-southwest alignment of the three main anticlines in the Peabody-Elbing district may be significant of the relation between their origin and the presence of the granite ridge a few miles to the east or it may indicate the presence of a similar ridge of somewhat lower elevation, as seems to be suggested by the presence of metamorphosed schist at 3355 feet in Milne No. 1 of the Watchorn Oil Co., in sec. 7, T. 22 S., R. 4 E.

While some small production has been obtained from higher sands, notably one in the Peabody-Elbing district in the Cherryvale shale, the main producing horizon of all these fields appears to be in the upper part of the pre-Pennsylvanian rocks which here may be older even than the Mississippian. The character of the material composing this horizon and the relative thinness of the Mississippian limestones indicate that a great deal of erosion has taken place. From the logs available it appears that the same conditions exist in the other southern Marion county and larger Butler county fields.

Two theories have been advanced in explanation of these conditions. A report (now in press) on the Eldorado field, by A. E. Fath, presents the view that the producing horizon of that field is a deposit of sand, chert, etc., on the truncated surface of the Mississippian and possibly older formations. Work done by Aurin, Clark and Trager, and published in the Bulletin of the American Association of Petroleum Geologists, Vol. V, No. 2, indicates that this sand horizon probably is the equivalent of some of the deeper productive horizons of Oklahoma and forms part of the Tyner formation of the Ordovician.

The samples examined from Urschel No. 4, show a considerable proportion of quartz sand from 2465 feet to 2600 feet with the exception of grey pyritiferous shale from 2495 to 2525 feet. There is a possibility that this sandstone should be correlated yith the Sylamore sadstone of upper Devonian or basal Mississippian age in northwestern Arkansas and northeastern Onlahoma. The Sylamore is described as consisting of translucent quartz grains, nearly always rounded, with light gray or blacn phosphatic pebbles and numerous rounded or angular pieces of chert. The following description of the Urschel samples cover the horizon in question.

2495-2525 Shale, grey, pyrite
2525-2530 Sand, glassy quartz

2530-2535 Sand, glassy quartz, iron stained
2535-2540 Sand, glassy quartz, well rounded, very limey
2540-2545 Sand, glassy quartz, iron stained, limey, some chert
2545-2565 Lime, sandy, glassy quartz, well rounded, some chert and pyrite
2565-2575, Lime, sandy, glassy quartz, well rounded, some chert and pyrite; slightly dolomitic
2575-2585 Lime, very sandy, glassy quartz, some chert
2585-2600 Sand, quartz, some chert, quite limey

The Chattanooga shale and the Sylamore locally contain pyrite in considerable abundance. One of the most noticeable characteristics of the shale immediately overlying the sand in the Urschel well is the presence of numerous small pyrite crystals. The Ordovician rocks which underlie the Chatanooga and Sylamore at the outcrop are described as magnesiam limestone and dolomite. However,, there was extremely little evidence of any dolomite in the limestone underlying the sandstone in the Urschel well. Whenever the Chattanooga has been definitely recognized, it has a very black color, but the shale in the Urshel well is gray. At best any correlation between this sand and the Sylamore must be tentative.

Up to the close of 1920, all the commercial production from this area was obtained from the southern Marion county fields. While the production from all these fields has been very important, that from the Florence-Urschel might have been much more so had not the present period of depression kept it from attaining its fullest development.

While the result of drilling in Morris, Geary, Dickinson, Chase and northern Marion counties has been uniformally discouraging up to the present time, the territory should not by any means be wholly and finally condemned. The work done in the Eldorado field, and information obtained by State Survey points to the conclusion that the chief influence of the granite on oil accumulation is exerted through the uplifting of the Mississippian and older rocks and the consequent erosion and reworking of the upper portion of those sediments. This action caused the concentration of the chert at the surface of the formation and solution produced porosity in the limestones, increasing the effective reservoir space for oil to a great extent. This was followed by the deposition of shales ranging in age from early Cherokee to Marmaton, depending on the degree of elevation undergone by the Mississippian. The problem, therefore, in the search for any fields adjacent to the granite ridge, is the location of areas where the Mississippian or older rocks have been rendered more or less porous by weathering, have been uplifted on the flanks of the granite and are now overlaid by shale or other adequate capping material. The lack of a sufficient quantity of carbonaceous shale and associated sands or other porous rocks is believed to have been the probable cause of the failure of well located tests of structures in Dickinson and other counties northwest of production in southern Marion county. There is still a possibility that some part of this area may have a sufficient thickness of rich shale to form an accumulation of commercial value and other counties have possibilities along this line. Perhaps eastern Chase and southeastern Morris counties offer the best chance of finding the right conditions on account

of their position with respect to the granite ridge and their proximity to territory where the source has been proved adequate to produce fields of importance.

D. W. Williams.

A NEW COMPASS FOR GEOLOGISTS

The firm of Breithaupt & Sons at Cassel, Germany, has constructed a new compass. The instrument has been designed according to specifications furnished by experienced field geologists to improve upon the existing makes and bids fair to become the most popular instrument of

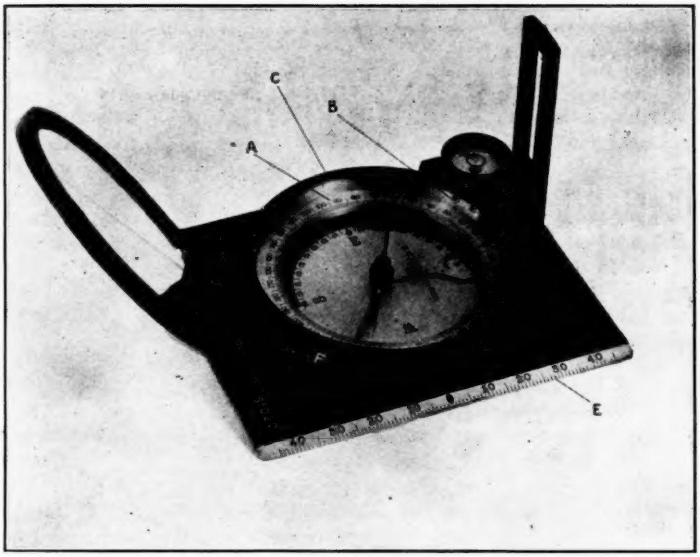

Fig. 1. The Breithaupt geologists' compass.

its kind among oil geologists in Europe. It is thought therefore that a brief description of the new compass may be of interest to the association.

The compass is of the same general type as the well known Gurley instrument, as shown in the accompanying illustration, (Fig. 1.) It also has the hinge sight and mirror of the Brunton compass. It has, however, the following additional noteworthy features:

(1). The compass circle (A) is divided into 360° reading counter clockwise, the same as is adapted for the geodetical transits which permits a more simple recording of readings as explained below. The dial

is adjustable to the various degrees of magnetic declination on a special unmovable scale (B) by a side screw (D).

(2). The compass box is water-tight closed by a screw cover (C) which permits of easy cleaning or adjusting the dip of the needle. The box is set on a square plate having one side graduated with a simple scale (E) very useful for plotting lines or points in the note book or on the mapping board.

(3). The needle is arrested by a small thumb screw (F) easy to set, so there is no tendency for the needle to loosen in the pocket thus rattling and wearing the pivot points as is commonly the case with the Brunton.

(4). The compass is equipped with a clinometer, which, when not in use is arrested by a small sliding bar not shown in the photograph. There is a small bubble on the side of the compass box for levelling.

(5). The instrument sells in Europe at a price about 1-3 that of the Brunton in America.

The circle division in 360° permits of the determination of direction by a single figure. In this way strike and dip readings are simplified inasmuch as only the angle of dip and direction of incline need be noted, as illustrated by the following example:

Say a bed is dipping at an angle of 15° in the direction East 47 South. It is sufficient to record simply 15°-137, and in publications or reports it may be simply written 15° SE (137) or 15°-137 (SE), the letters SE sufficing to picture the general direction in the mind of the reader, while the figure 137 registers the exact number of degrees from astronomic north, the magnetic declination being eliminated.

This method of recording compass readings by using this new type of circle division is taken from a more detailed article published by Dr. O. Dreher, The Hague, Holland. This compass is so similar to the Gurley instrument which has never been popular in this country that it will probably never be used here.

F. B. Plummer.

SUPPOSED IGNEOUS ROCK FROM WICHITA COUNTY, TEXAS WELLS

Mr. Pratt's note on the supposed evidence of the volcanic origin of the Gulf Coast Salt Domes, appearing in the January-February issue of the Bulletin, came as a distinct surprise to the writer. The data upon which the present memorandum is based, were at hand, and except for a mishap in securing the accompanying photographs, would have been submitted for publication in the same issue. The question of the origin of salt domes is not here involved, but the conclusion is substantially in agreement with Mr. Pratt's view. The writer was not previously aware that the supposed igneous material had been found in such numerous instances in the Coastal area.

The specimen shown in the photographs is a fragment of a 4-inch

Plate 1. Specimens of rock from core barrel metamorphosed by heat from drilling.

core taken from a depth of about 1850 feet in Dee & Bellport's No. 3 Mangold, located three miles west and a little south of the K-M-A field in southwestern Wichita county, Texas. It shows the character of a portion of the core which represented a "break" several feet in thickness in the midst of a sand containing a light showing of oil. The photographs show opposite sides of the same specimen, very slightly reduced in size. The curvature of the core barrel is shown by the rounded outer margin of the fan-shaped specimen; the center of the core, by the convergence of the radial lines. The material in Plate I*A* is blue-gray in color, but has a brownish discoloration and a somewhat vitreous appearance in Plate I*B*.

If this specimen had been found on the surface in a region where lava is common, it is safe to say that it would promptly have been classed as igneous material by most geologists. The only feature which might possibly have aroused curiosity would have been the peculiar radial fracture. In Plate I*B* the scoriaceous, pitted texture is clearly shown. Fusion has not progressed to the glassy stage, however.

In its unaltered condition, this formation was, without much doubt, an ordinary blue shale, with perhaps more or less sand disseminated through it. The several light-colored, angular inclusions are evidently fragments of siliceous limestone from higher up in the hole. The lighter-colored laminations in the shale, prominent in Plate I*A*, were disturbed by the rotation of the pipe, and appear in the photograph as concentric, wavy lines.

The fracture shown is very interesting and shows a remarkable similarity to basaltic columnar structure. The probability is that the structure is typically columnar and is due to the same cause as the basaltic type. The core barrel, working in the hard overlying sand, became sufficiently heated to fuse and clinker the shale when it was penetrated. The heat generated by friction in the sand, no doubt considerably expanded the core barrel, and with this expanded diameter it cut into the shale. In pulling out, the cold wall of the hole soon chilled and contracted the metal, thus subjecting the hardening, partially fused core to more or less pressure. The core cooled unequally from its outer periphery inward toward the center, with contraction greatest in the outer zone. This unequal contraction was no doubt the cause for the development of the miniature columnar structure. The core when removed from the hole, was hard and brittle, and a light blow served to break it up into pencil-like splinters along the cleavage planes. The central portion of the core which was probably never so hot as the outer portion, showed no tendency toward the development of cleavage.

An interesting speculation arises as to the degree of heat necessary to bring about this metamorphism. Kent's Manual gives the heat of fusion of iron as ranging between 2000 and 2500 degrees F., depending upon the carbon content. The same authority gives the interior temperature of a kiln for burning ordinary red brick as about 2000 degrees

F. The core barrel was not available for inspection, but the writer was assured that it showed evidence of a slight flowage of the metal. Evidently, then, the temperature at the bottom of the hole was near 2000 degrees F., or possibly somewhat higher.

Specimens of similarly metamorphosed shale from several wells in the Burkburnett Northwest Extension have been examined by the writer. These samples, also taken from cores, were not scoriaceous but showed a tendency toward fusion.

The evidence is quite sufficient to convince the writer that in areas where rotary drilling is practiced, reports of igneous rock should be discounted and carefully investigated, as there is ample evidence that sufficient frictional heat may be generated underground, particularly in the use of a core barrel, to cause both fusion of shale and sand. This is particularly likely to occur where for any reason the circulation from the pumps does not reach the bottom of the hole, and the cutting edge is working in relatively dry material. No doubt fusion takes place in different shales and sands at different temperatures, depending upon their chemical composition. Conceivably, then, certain strata might be metamorphosed by a temperature which would be insufficient to fuse immediately overlying or underlying strata of apparently the same character; only a chemical analysis could settle this question. But in certain instances, it is thought that sufficient heat may be generated by friction alone to fuse and metamorphose the average shale encountered.

Thanks are due Mr. Ernest Closuit for having called attention to the above occurence, and for the loan of the specimen used in making the photographs.

W. E. Wrather.

A SIMPLE METHOD OF TAKING CORES IN WELLS BEING DRILLED BY THE ROTARY SYSTEM

Geologists are inclined to distrust the drilling of wildcat wells by the rotary system. Poor samples of the formations penetrated by the drill are usually secured, it is difficult to determine the depth from which the samples come, oil bearing formations are often passed through without being observed or tested, and experience has shown that only too often, a rotary drilled hole is an inadequate, incomplete, and inconclusive test.

In certain regions, where the subsoil consists for the most part of soft or unconsolidated sediments such as the Gulf Coastal Plain, drilling by the standard cable-tool system is not practicable nor feasible, however, and the problem of wildcat drilling resolves itself into one of drilling with a rotary and keeping the operation under such close observation as is possible. The taking of cores has come to be considered extremely important and, in the best practice, cores are frequently taken in wells drilled in developed fields as well as those drilled for exploratory purposes.

A very simple, inexpensive, and effective type of core barrel, which has been developed by the oil field workers in the Coastal fields, is known as the saw-tooth or basket type of core-barrel (Fig. 1). It consists simply

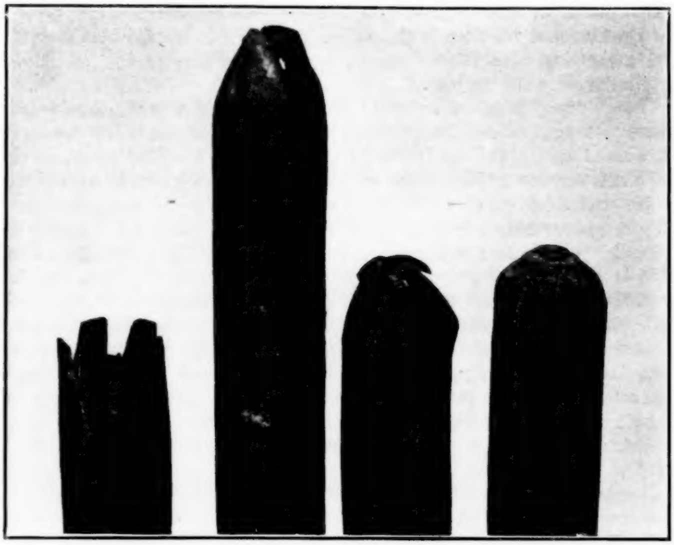

Fig. 1. Photograph showing open and closed barrels.

of a piece of ordinary drill stem or wrought iron pipe, usually 4 to 10 feet in length, with teeth cut on its open end. The upper end of this barrel is attached to the drill stem by a collar and the barrel is run into the hole and rotated until the core is cut. The barrel is then closed by letting part or all of the weight of the drill stem rest on bottom and continuing to rotate slowly. This causes the teeth to bend inward and overlap one another after the fashion of a basket weave, thus securing the core.

After the drill stem has been withdrawn from the well, the core barrel is unscrewed and the core removed through its open end. The closed end of the core barrel may then be cut off and the barrel redressed and this operation can be repeated until the barrel is too short for further use.

The dressed end of a core barrel of this type with five teeth is shown in Fig. 1A. Partial closure of the same type of barrel is shown in Fig. 1B and perfect closure of a three toothed barrel is shown by Fig. 1C.

Much of the success of this method of taking cores depends upon the manner in which the cutting edge of the barrel is dressed as well as upon the skill of the driller taking the core. Barrels for taking cores in

soft formations are usually dressed with 5 to 9 long teeth as shown by Fig. 1A. or the teeth may have sharp points. Barrels for taking cores in hard rock usually have three short flat teeth or, for very hard rock, a single notch, as described by Suman[1]. If too few and too short teeth are used in soft formations, failure to secure perfect closure often results and if too many and too long teeth are used on hard rock, premature closure and failure to secure a core generally results.

Core barrels of this type should have small holes near the collar to provide for circulation after the lower end of the barrel is stopped by the core.

Figs. 1D and 2 are of a four toothed barrel which ran into hard rock

Fig. 2. A core barrel closed before securing core and welded by frictional heat.

and was closed before securing a core. After closing, it was rotated for 25 minutes against the rock and the closed teeth were welded together by the frictional heat. The writer has the end of a six toothed barrel which shows a perfect water-tight weld as the result of frictional heat.

Core barrels made from steel pipe should be annealed so that the teeth will bend easily. For hard formations, the cutting end of core barrels should be case hardened.

These core barrels are generally made in a blacksmith shop but may be made on the derrick floor, a small oxy-acetylene outfit being used for cutting the teeth. The latter procedure has much to recommend it since the driller will dress the barrel for the particular formation to be cored and does not have to keep an assortment of core barrels on hand. The total cost of one of these barrels is about $12.00 depending upon length. The usual charge for redressing is $3.00.

[1]Suman, John R. Taking accurate samples in rotary drilling. The Oil Weekly, pp 47-48, Houston, Texas, July 3, 1920.

In running this type of barrel, great care should be taken in going into the hole as the sharp pointed teeth are prone to catch on the sides of the open hole and become bent before any core has been taken. After running in, the barrel is usually held just off bottom and thick mud pumped through for 20 or 30 minutes in order to clear the hole of cuttings or cavings. The barrel is then rotated and gradually lowered until the desired length of core has been cut. In order to start closure the partial weight of the drill stem is allowed to rest on the barrel while rotating and before being withdrawn the drill stem is usually spudded two or three times in order to insure complete closure.

There would seem to be no reason why cores should not be taken with the basket barrel of as great length as can be taken by most other core taking devices for use with the rotary system. The length of cores generally taken, however, is 2 to 4 feet and core barrels 4 to 6 feet in length are most commonly used.

E. DeGolyer.

MEASURING METER FOR DRILLING WELLS

Mr. R. C. Mason, of Tulsa, Okla., has recently invented the measuring

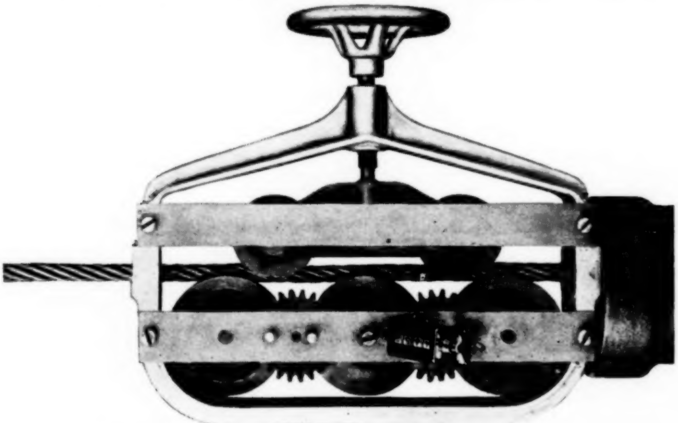

Fig. 1. Mason measure meter for measuring depth of oil and gas wells.

meter for oil wells shown in Fig. 1. As shown in the Figure this machine can be attached to any line being run in or out of a well by screwing in the driving wheels on the right. The weight of the machine, 36 pounds, holds it on the mouth of the well and in case of raising the tools or bailer so rapidly that they hit the bottom of the machine the latter rises with them. The meter is attached to the center wheel spindle and

reads to four places. It can be set to zero and will read normally when the line is being run down the hole. When coming out of the hole the machine can be reversed. This invention will save many hours in removing tools from the hole and will accurately record the depth of formations. With its aid a geologist can readily check the depth of many drilling wells in a field in one day with a limit of error of about 1:1,000.

Sidney Powers.

COLLAPSIBLE BIT AND CORING DEVICE FOR ROTARY DRILLING

J. C. Stokes, an electrician of Shreveport, Louisiana, has invented a fish tail bit together with a coring device for rotary drilling that operates in and out of the hole through the drill stem on an ordinary bailing line, by means of a drum made for the purpose (Fig. 1) The drum is placed on the derrick floor between the drilling drum and the rotary, and in a position that enables the driller to operate without changing his position. This arrangement eliminates the necessity of removing the drilling line and the bailing line from their respective drums, consequently it saves much wear and tear on the line, besides much time and labor. Both lines are ready for instant use and easily put in action at any time. When the bit reaches the especially designed collar at the bottom of the drill stem it spreads to gauge, and releases the over-shot which with the bailing line is used to operate the tool in and out of the hole. The over-shot is then removed from the hole to await the time to go in and recover the bit, when a change of bits is desired.

Although this invention is designed principally to avoid the necessity of pulling the drill stem out of the hole to change bits, its operation in drilling a number of wells successfully through all formations proves itself to be a great saver of time, labor, wear and tear on rig, fuel and money. Time is saved as it requires an average of thirty minutes each time the bit is changed, in drilling a well of 2,500 feet in depth, while it requires an average of not less than two and one-half hours each time the bit is changed in a 2,500 foot hole using the old method of removing the drill stem. Labor is saved because the steam power does the most of the work in changing the bit. Also the use of this new bit eliminates the upset drill stem and tool joints together with the labor necessary for maintenance and repairs. Non-upset drill pipe of National quality is used as drill stem and then set as casing. The saving of wear and tear of the rig together with saving of fuel is very apparent, as going in and out of the hole with the drill stem each time requires much steam power. A further saving is due to the fact that no taller derrick is needed than is required to operate the well after completion.

The coring device which is simply a core barrel of any design substituted for the blades, merits special stress as with it a core can be taken quickly at any stage of the drilling. As this drilling equipment is used from the top to the bottom of the hole, through all formations, it is

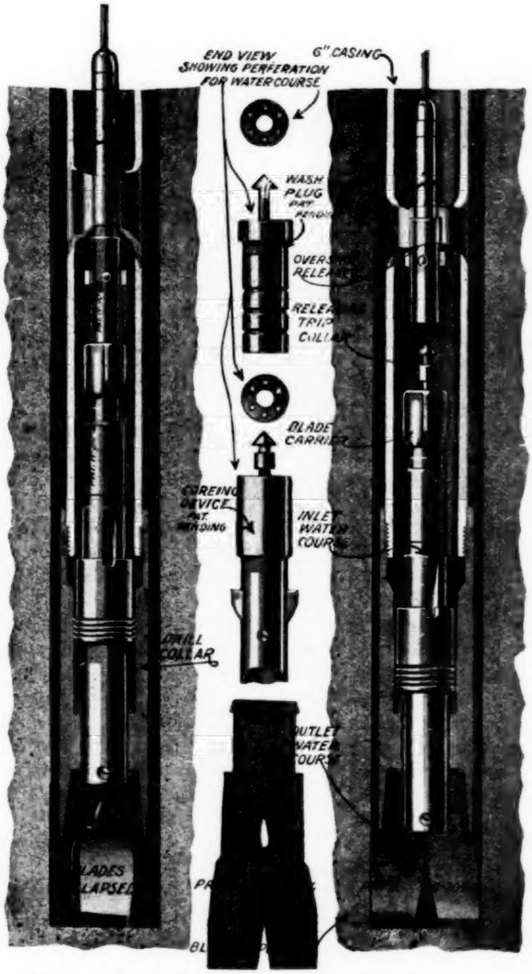

Fig. 1. The Stokes rotary drill and collapsible bit.

quite apparent that the core device is of more than ordinary value in prospecting for all kinds of minerals. It is especially important to the oil operators in rotary countries where, heretofore, coring has been impracticable because of time and expense required to take the core. It is

necessary to take a core to distinguish positively sand from shale, and a core of sand will frequently show oil although none shows on the ditch in the return water. Furthermore, the ordinary bit cuts the sand so fine that it cannot be caught in the cutting bucket, and if found in the cutting bucket it is impossible to tell the depth from which it came.

Another commendable feature of this bit is that it is in itself a very effective underreamer because the maximum hole cut is just twice the diameter of the pipe used for drill stem, less one-half inch. Thus, if an oil sand has been mudded off it is possible to break down the mud wall by enlarging a 5⅞ inch hole to 7½ inches. Drills can be made to fit any size of pipe. The simplicity of the construction enables it usually to withstand the rough treatment necessary in drilling through hard formations. Its ease of operation in addition to its coring feature, and its material reduction of the cost of drilling wells makes it a modern invention which should eventually be a great success. The only drawback is the fact that the blades occasionally break off and are difficult to fish out or drill up.

Elton Rhine.

REVIEWS AND NEW PUBLICATIONS

A Preliminary Report on the Oil Shales of Kentucky, by W. R. Jillson. Economic Papers on Kentucky Geology, Kentucky Geological Survey, series 6, 1921, pp. 1-38.

"Using the computed outcrop acreage of the Devonian black shale in Kentucky as 609,920 acres, and assuming empirically a thickness of 20 feet, ... a total tonnage figure may be obtained for this state that is stupendous. The average oil content of 16.08 gallons per ton when multiplied into this tonnage gives a possible recoverable quantity of tarry oil of 12,308,217,065 barrels, or at least twice the amount of the petroleum now estimated to be still available in the ground in all the oil fields of the United States."

With this statement, Mr. Jillson claims Kentucky as a rival of the more widely advertised states of the West for recognition as a future source of oil when the present fluid supply shall have failed, and the distillation of shale shall be of commercial importance.

This paper deals briefly with the formations in Kentucky available for the distillation of shale oil, notes the tonnage of shale within easy access, and summarizes the results of destructive distillation of several samples taken from widely separated localities within the state. The treatment is entirely general and preliminary in nature, but it serves the purpose of the article, which is to call the attention of the layman as well as the professional oil man to the fact that Kentucky has an oil reserve that will merit close atention before many years have passed.

The geological horizons which have possibilities are three in number; unnamed cannel shales in the Pottsville formation of basal Pennsylvanian age, the Sunbury shale of early Mississippian age, and the Devonian black shale of Upper Devonian age. The Pottsville cannel shales are dismissed with brief mention, due to their extreme thinness, 1 foot to 5 feet, and the necessity for their recovery by drift mining. However, selected specimens have produced 40-50 gallons of crude distillate per ton. The Sunbury shale is discussed with the Devonian black shale, owing to their similarity, and their stratigraphic unity throughout much of the state.

The one important horizon is the Devonian black shale, generally called Chattanooga shale in Kentucky and Tennessee. This very fissile, dark brown to black shale, varies from twenty to seventy-five feet in thickness along most of its outcrop, which occurs in 33 counties in the center of the state. The accompanying map, (Fig. 1) shows the shale in black outcropping in a horseshoe about the "Blue Grass," the only portion of the state where it is known to be wanting. Over 650,000 acres are exposed, and with light stripping about 600,000 acres of high-grade shale are available for steam shovel operations.

Distillation and analysis of twenty samples of the Devonian black shale from almost as many different counties give the following results:

	Maximum	Minimum	Average	
Oil content	27.75	8.00	16.08	gal. per ton
Spec. Gravity	2.406	1.966	2.173	
Weight	149.85	122.59	129.37	lbs. per cu. ft.
Sulphur	4.15%	1.50%		
Combustible matter	16.72	10.26		
Fixed carbon	10.06	4.61		
Ash	83.90	73.43		

Fig. 1—Outline map of Kentucky showing the outcrop of the Devonian black shale.

The results are tabulated by counties in the paper but the samples are too few to justify any such division of the state at present. No attempt was made to determine variations at different horizons in the same vertical section, the samples being taken without reference to the posi-

tion occupied in the formation. Thus a good general impression of the possibilities of the Devonian black shale as a whole is given.

Though the oil content of the most important oil shale of Kentucky is less than one fourth that of the western shales, the proximity to the eastern markets is expected to make Kentucky shale oil a strong competitor and a commercial success, and certainly Mr. Jillson's figures indicate that there is a vast amount of shale oil that may be recovered eventually.

John L. Ferguson.

Oil-bearing rocks of Lower Mackenzie River valley, E. M. Kindle and T. O. Bosworth, Geological Survey of Canada, Summary Report, 1920, pt. B, pp. 37-58.

The Fort Norman oil well of the Imperial Oil Company has created great interest in northwestern Canada. The credit for the geologic work in connection with this location is given to T. O. Bosworth and T. A. Link, who have studied the little-known portions of Canada at various times since 1913. The oil well was completed at the end of the season of 1920 on the east bank of the Mackenzie River, forty miles north of Norman, one hundred miles south of the Arctic circle, and sixty miles farther north than the Klondike gold field, which is three hundred and fifty miles west (Fig. 1). This region is about one thousand miles north of the famous Athabaska tar sands in the basal Dakota sandstone which lies directly on Devonian limestone. The well is 1200 miles from McMurray where the telegraph and railroad stop. The navigation of the Mackenzie River extends from July 1st to October 1st.

The stratigraphy is shown in the following table:

Table of Formation Exposed in Lower Mackenzie River Valley.

Tertiary		Shales, sandstones and lignite	Thickness
Cretaceous		Clay shales and sandstones	
Upper Devonian	Bosworth sandstone and shale	Greenish and vari-colored clay shales and sandstones with marine shells and plant fragments. Well penetrated 255 feet of this formation	2000x
	Fort Creek shales	Bituminous shales, with thin seams of dark limestone. Black or dark, but in places burnt brick-red. Plants and marine shells, common. Oil well 528 feet below top this formation	500-1,0000
Middle Devonian	Beavertail limestone	Hard, thick and thin, bituminous limestones with some shale partings. Black or dark grey	350
	Ramparts limestones	Compact grey limestones, not petroliferous	250

Middle Devonian	Hare Indian River shales	Calcareous clay-shales with thin seams of limestone. Not petroliferous. Grey-green colour	300x
Silurian	Bear Mountain formation	Brecciated dolomite with hard grey limestone, gypsum, etc. Not petroliferous	1,600
	Lone Mountain dolomite	Sandy magnesian limestone, dark grey and buff, without fossils. Not petroliferous	1,800

The structure of this region is steeply folded with alternating anticlines and synclines of the Appalachian type seven miles from crest to crest of the anticlines. The reversal from crest to trough must be about five thousand to ten thousand feet. As shown in Figure 1, there are four folds crossing the river and the anticline northeast of the discovery well is probably a continuation of the southern most of the other four anticlines shown in this figure. The dips on the sides of the folds vary from five to eighty-five degrees and each fold stands out as a mountain with about one thousand feet of relief. The age of the folding was in a large part pre-Cretaceous.

Petroleum is found very generally in the Canadian Northwest in the Devonian limestone here named the Beavertail. Fluid oil and seepages are absent from these beds. The overlying richly bituminous black shales yield a bituminous odor which sometimes is so strong that it is noticeable at a distance of one-half mile. The discovery well found oil throughout the 528 feet of shales of this formation passed through, and many barrels of oil were bailed. The flow of oil at a depth of 783 feet shot over the derrick through six inch casing for ten minutes. No report of sand is given and therefore the oil probably comes from completely saturated sandy shale.

Sandstones of the Bosworth beds are sometimes saturated with high gravity oil which is almost colorless in contrast with the 36-degree Baume gravity oil of the discovery well.

The discovery well was located eight miles southeast from the crest of the discovery anticline in such a place that it would penetrate the petroleum-bearing formations. There was some evidence of minor undulation at this point. The well was drilled with a machine.

The most significant features of the geology are: first, that the petroliferous formation have been completely eroded from the anticlines shown in Figure 1, and second, that no sandstones are described in the oil bearing shales. Unless accumulation of oil in very large quantity is found down the dip from the outcrop, as in certain California fields, it will be necessary to search for minor folds in which the oil bearing strata have not been uncovered by erosion. The discovery well was permitted to flow only three times and therefore the estimated production of six hundred barrels per day is problematical. The long distance from civilization and the short open season will hinder the exploitation of this region for several years to come. Sidney Powers.

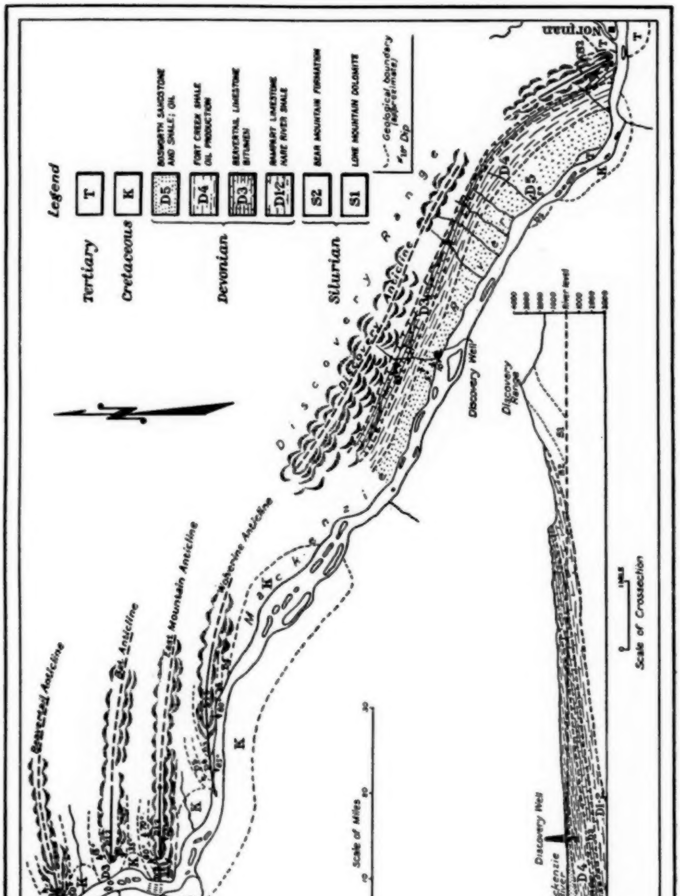

Fig. 1—Geological map of a portion of the Lower Mackenzie River valley showing the new Fort Norman oil well. The cross-section shows the relation of the producing horizon to structure.

AT HOME AND ABROAD

MR. E. T. DUMBLE is Consulting Geologist and MR. J. A. TAFF is Chief Geologist of the newly formed Pacific Oil Company.

MR. F. A. EDSON has resigned from the Oklahoma Geological Survey and has gone to Mexico.

MR. F. R. REES has resumed his practice as consulting geologist in Tulsa.

MR. C. H. WEGEMANN is geologist for the Western States Oil and Land Co., of Denver, Colorado.

MR. RAYMOND C. MOORE has been engaged during the summer in work for the U. S. Geological Survey in southern Utah. His party, with pack train outfit, made a detailed survey of the Circle Cliffs structure on which the Ohio Oil Company is now drilling a test well and completed a reconnaissance geological survey of a considerable part of eastern Kane, Garfield and Wayne counties, Utah. During his absence MR. SIDNEY POWERS, Associate Editor of the Bulletin has supervised the editorial work.

MR. M. G. CHENEY is spending the summer in New York State.

MR. A. E. HARTMAN has been ill for several months at his home in Fort Worth. He is now greatly improved in health.

MR. CLIFTON W. CLARK has been working for the Panhandle Oil and Refining Co., in West Texas.

MR. ARTHUR K. ADAMS, mining geologist, who spent a number of years in South America and who was recently employed by the Sinclair interests in Costa Rica, died of tropical fever in Costa Rica, Nov. 2, 1920.

MR. VAN DER GRACHT and MR. R. A. CONKLING examined in an airplane the Hall County, Texas, structure discovered by MR. WILL BUTTRAM. They pronounce airplane geology a success. MR. WILLIS T. LEE of the U. S. Geological Survey has also used an airplane for geological work along the Atlantic Coast.

MR. F. A. A. VAN GOGH is now Chief Geologist for the Royal Dutch-Shell Oil Co. MR. J. T. ERB has been made a director.

MESSRS. L. R. DAWSON, GEORGE STEPHENS, and BOONE JONES have formed the Oklahoma Geological Association at Oklahoma City for the purpose of general geological work

MR. J. M. NISBET, of the Empire Gas and Fuel Co., has been transferred from Houston to Arkansas and Oklahoma with headquarters at Bartlesville.

MR. O. N. WALLACE, formerly with the Empire Gas and Fuel Co., in Houston, has gone to Venezuela with the British Equatorial Oil Co.

THE HUMBLE OIL AND REFINING Co. has moved into its new building in Houston and MR. W. E. PRATT is in room 911.

THE SOUTHERN DIVISION of the Amerada Petroleum Corporation has been moved to the third floor of the new Humble Building in Houston.

MR. J. B. OVERSTREET, formerly with the Sun Co., is now Chief Geologist for the Houston Oil Co., with headquarters in Houston.

MR. W. E. DICKIE is Division Geologist for the Sun Co., at Beaumont.
MR. F. B. PLUMMER is in Switzerland.

MR. J. B. BURNETT is working on the Isthmus of Tehauntepec, for the Mexican-Eagle Oil Company.

MR. A. L. BRACE is with the Agwi with headquarters at Tampico.

MR. A. C. BIERMAN is associated with Darnell & Eaton at 170 Broadway, New York City.

MR. HENRY HINDS is Chief Geologist for the Pantepec Petroleum Company at Tampico.

MR. RALPH RICHARDS has returned to Washington, D. C., after an extended trip through Algeria. He is located in the Westory Bldg.

MR. JOHN L. FERGUSON is engaged in consulting work at 618 South Adams St., Spokane, Washington. For several years Mr. Ferguson has been associated with MR. C. N. GOULD.

MR. ELIOT BLACKWELDER will teach at Harvard University during the first term next year, taking the place of Professor R. A. Daly, who is in South America.

MR. J. V. HOWELL has secured an appointment as Professor of Economic Geology at the University of Iowa. It is to be hoped that Mr. Howell will not train many oil geologists for competition with those now out of work during these hard times.

MR. ROBERT WOOD is spending the summer in the East.

MR. C. A. BAIRD is with the Mexican Eagle Oil Co., in Mexico.

MR. BEN C. BELT has resigned from the Gulf Oil Corporation and is now in Mexico.

MR. R. A. LIDDLE, formerly of the Bureau of Economic Geology, Austin, Texas, is now with the Carter Oil Co. on foreign work.

MR. R. D. LONGYEAR, of Minneapolis, Minn., has been endeavoring to perfect a machine for diamond drilling which will cut large holes. Such

machines have been in use in Belgium for many years and were used there by the Geological Corps of the German army during the war to test thoroughly for coal.

Mr. L. G. Huntley is now in Mexico.

Mr. L. C. Glenn is making a survey of the Red River for the State of Oklahoma, in connection with the Oklahoma-Texas boundary dispute.

Mr. Donald F. MacDonald recently returned to New York after an extended trip through southern Mexico for the Mexican Sinclair interests.

Mr. Roderick Crandall is in charge of the Sinclair exploration work in Angola, West Africa.

Mr. A. H. Fray has been appointed chief of the Natural Resources sub-division of the Internal Revenue Bureau.

Prof. E. F. Schramm of the University of Nebraska, is drilling the well in western Nebraska.

Mr. Paul Weaver, Chief Geologist of the Mexican Eagle Oil Company has been in New York on a business trip. He has invented a spider bushing for use in connection with the Mexican gushers to keep them from blowing casing out of the hole.

Messrs. Harve Loomis and Burton Hartley are taking a trip through Wyoming.

Mr. R. S. Knappen is mapping Grant County, Oklahoma, for the U. S. Geological Survey.

Mr. Geo. L. Green is now with the Marland Company in Mexico.

Mr. W. A. ver Weibe is Chief Geologist of the Mexican Sinclair Oil Company.

The Geologists of the Shell Company of California, located the new Sunset Hill field.

Mr. John K. Knox is now in the Himalayan Mts. recuperating from an attack of malaria contracted in Baluchistan. Mr. Knox reports that geologists can do only about five months of active field work because of the intensity of the heat on the plains of India.

Mr. E. P. Rothrock, who has been working for the Washignton Oil Company in Kentucky, has gone to Cimarron County, Oklahoma, to complete some work started last summer for the Oklahoma Geological Survey.

Mr. Max A. Pishel is now located at 1044 21st St., San Diego, Calif.

Mr. L. P. Andresen, of the Carter Oil Co., has moved to Denver, Colo.

Mr. S. J. Caudill has moved his office to 636 Kennedy Bldg., Tulsa. He has been in Washington on the tariff investigation.

Mr. Jon A. Udden announces the program for the fall meetings of the Tulsa section of the American Institute of Mining and Metallurgical Engineers as follows:

September 30th, 1921: Mowry Bates, The Outlook for the Oil Industry; Chas. T. Kirk, Subsurface Structure of Southern Arkansas.

October 28th, 1921: Jon A. Udden, Some additional notes on the geology of Northern Alabama as determined by recent drilling by the Sinclair Oil & Gas Company; J. R. Pemberton, Cause, prevention and treatment of B.S.

November 25th, 1921: M. M. Valerius, The Relation of the Mid-Continent fields to major Structures; Alf. G. Haggem, Some Recent Oil and Gas Conservation Apparatus.

December 23rd, 1921: J. H. Gardner, General Geology of the Osage Nation; H. B. Goodrich, Shooting of Oil Wells.

Mr. Robert T. Hill has given up his office at Dallas and has moved to California. He is at present at Longbeach.

Mr. W. E. Wrather spent the summer in Alaska.

Mr. H. H. Adams has given up his offices at Ranger and at Duncan and is now located at 415 W. T. Waggoner Bld'g., Ft. Worth, Texas.

Mr. J. Y. Snyder of Shreveport, Louisiana, has been elected a Director of the Commercial National Bank of that city.

The firm of Brokaw, Dixon, Donnelly, Garner, and McKee have moved their offices from 90 West Street to 120 Broadway, New York City.

Mr. L. B. Laird is now in Mexico.

Mr. Glenn Laskey is now at Haynesville, Louisiana.

Mr. Robert Thompson is with the Texas & Pacific Oil Company at Thurber, Texas.

Mr. D. D. Condit is in India with the Whitehall Petroleum Corporation.

Mr. Frank Parsons is representing the Western Oil Fields Corp. at Mexia, Texas.

Messrs. W. P. Haynes F. B. Ely and C. W. Boughton are in Guatemala.

Mr. S. G. Garrett represented the Fensland Oil Co., at the Osage auction sale June 14th.

MR. R. T. HILL has left Dallas to reside permanently in Los Angeles. He has spent several months in West Texas working on the correlation of the Mexican and Coastal Plain Cretaceous sections and the results of the work are being published by the Bureau of Economic Geology, Austin.

MR. W. E. WRATHER is spending the summer in Alaska.

MR. ELIOT BLACKWELDER is drilling several wells near Iola, Kansas.

MR. F. W. GARNJOST is spending the summer at Spuyten Duyvil, New York City.

MR. ARTHUR IDDINGS is resident geologist for the International Petroleum Co. at Medellin, Columbia.

MR. E. L. PORCH, JR., is with the Mexican Eagle Oil Co. at Tampico, Mexico.

MR. A. C. BIERMAN is associated with Mr. Arthur Eaton at 170 Broadway, New York City.

MR. E. RUSSELL LLOYD is Chief Geologist of the Mid-Kansas Oil Co., with heauquarters at Augusta, Kansas.

MR. W. B. EMERY, geologist with the Ohio Oil Co., is working in Utah with headquarters at Casper, Wyo.

MR. WALLACE LEE has resigned from the Plateau Oil Co.

MR. W. W. RUBEY of the U. S. Geological Survey is working in Arkansas.

MR. F. B. PLUMMER is in Switzerland.

At a meeting of the Institution of Petroleum Technologists held on Tuesday evening, the 19th of May, at the Royal Society of Arts the following paper was read: "Trinidad as a Key to the Origin of Petroleum" by Prof. P. Carmody.